# METALS and ALLOYS

The Engineering Magazine of the Metal Industries

JULY 1943

Metal Production · Metal Working · Materials and Design

E. Eng. Lib.
Faxon

# METALS and ALLOYS

**The Engineering Magazine of the Metal Industries**




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### This Month



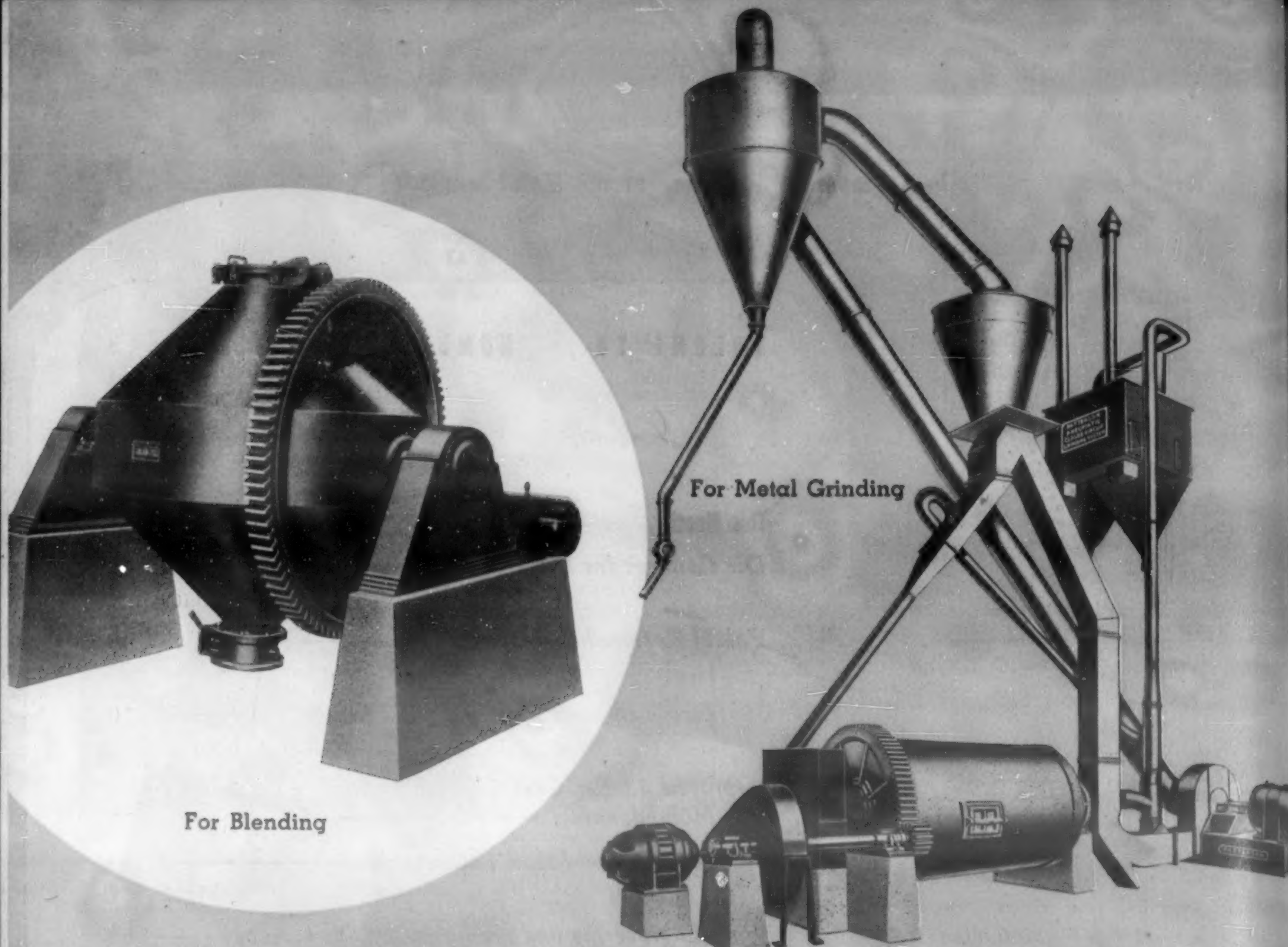
*ENGINEERING FILE FACTS*

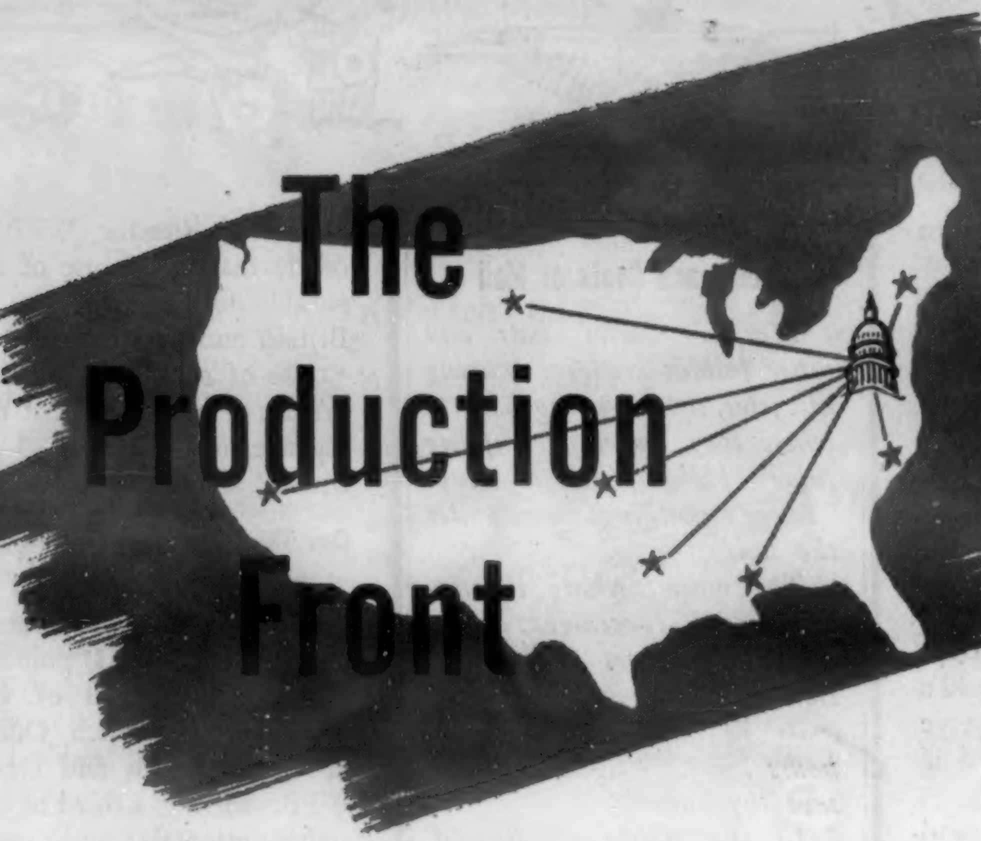


### Every Month



### Metallurgical Engineering Digest


For Blending
For Metal Grinding



# The Production Front

by Harold A. Knight
*News Editor*

*Washington tries to counteract over-confidence on production. . . . 50 per cent over-all increase for second half. . . . Green lights for million more tons of carbon steel in third quarter. . . . Outside steel, raw materials situation is good. . . . Magnesium is almost drug on the market.*

*We're straining for some dozen items from airplanes to valves. . . . Plane output 100 per cent greater than 1942. . . . Let's tell the enemy our real facts on production! . . . British use relatively more NE steels than we. . . . Lithium, indium, osmium and others are "made" by the war. . . . Only good nations should get plenty of metals.*

*Thoughts on stock-piling. . . . "Absenteeism" is the cart before the horse. . . . Lend-lease not all one way. . . . Talk of plate output slowdown unwarranted. . . . Plant gadgets for women also help men. . . . Just try to schedule steel for a battleship! . . . Steel production by districts. . . . New Canadian 5-cent coin.*

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### Keep Up the Production Offensive!

The vice presidents in charge of production, the shop superintendents and foremen of our production front in Washington, so to speak, have suddenly become alarmed at the feeling of national smugness over our output of aircraft, ships, guns and tanks, and have recently been whipping us people into accelerated action. These same leaders are perhaps partly at fault themselves. They had thrown out more than veiled hints two months before that by Fall we could slow down war production in many items and turn partially, at least, to civilian goods manufacture. Americans, who invariably do things in extreme, were beginning to run away with this idea.

War production drives, with management cooperating with labor, are again revived, and the aim of over-all war production for the second half of 1943 is 50 per cent over that of the first half.

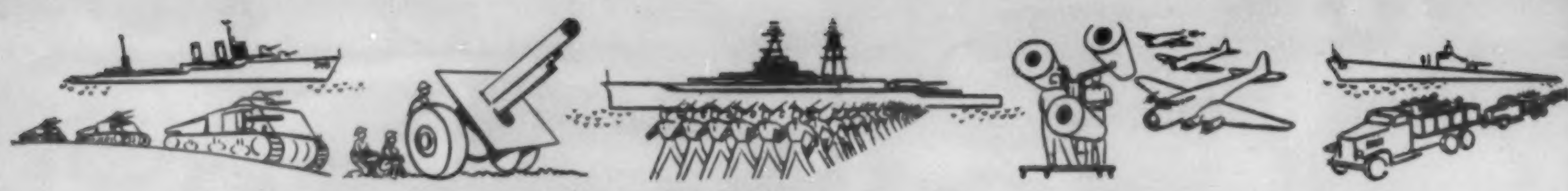
Plain carbon steel is the No. 1-A primary, principal, preferential and outstanding need of the hour, and the green lights have been switched on to give new plants in process of construction the necessary components and gadgets and eliminate the impediments in order to start flowing the molten steel out of the tap holes. Open-hearth and electric furnaces are the double A's of the program. One million more tons of steel must be produced in the third quarter than in the second, with the ante raised another million — just like that! — in the fourth quarter.

#### Raw Materials Situation Good

Aside from steel, at no time during pre-Pearl Harbor can one recall when the nation was more relaxed on the raw materials situation. As to all reasonable needs in sight, there is a fair abundance, though perhaps we are blurting out a truth that had best be suppressed for policy sake. We'll have 3,000,000 tons of copper for 1943, for instance.

Magnesium is so plentiful that anyone who feels he needs it better ask for it — he may be surprised how easily he gets it. Magnesium is perhaps typical of many critical commodities. Production before the war was 4,000,000 lbs. yearly. Our capacity to produce now is 150 times our capacity to consume then.

In fact, magnesium is being produced at 5 to 10 times expected production here in mid-1943. WPB looked for only two-thirds of the projected plants to be in production by now. Instead, all are producing — with an average of 80 per cent capacity, and with one or two at over 100 per cent of rated capacity. In fact, it may be a problem of both war-time and peace what to do with



all this metal. After all, magnesium is two-fifths of the earth's crust.

#### We Have Huge Potential Reservoir

Every metal, except tin, is available in greater quantity than before the war, said Dr. Zay Jeffries, of General Electric Co., Nela Park, Ohio, recently, who stated decidedly that we will have enough metal to win the war. He pointed out further that metals already in use in the United States, from ash trays to steel bridges, form the world's greatest metal stockpile — a reserve that can be scrapped and tapped if supplies get desperate.

It is still the components and items between the raw materials and finished products stage where the chief bottlenecks still exist. When interviewing several WPB and other officials, we jotted down the critical items that came from their lips in a way to show these were most on their minds (though they did not attempt to give us an orderly and complete enumeration). These were: valves, heat-exchangers, merchant and naval ships, airplanes, 100-octane gas, synthetic rubber, extrusions and forgings for airplanes, turbines, precision aircraft parts, diesel engine parts and gears.

How the late Billy Mitchell was again corroborated is the fact that 33 per cent of all munitions produced in April was aircraft and related items, totaling $1,649,000,000 — but even this did not quite meet the month's objective. Plane production now is 100 per cent greater as to *units* than in 1942, but based on *weight* of planes, three times as great. Our ship production in May was 1,750,000 deadweight tons — a figure that will be hard to beat.

#### Pull Out the Stops on Statistics

And — speaking of production — Gardner Cowles, shortly before leaving the Office of War Information to return to his publishing business in Des Moines, told us that the Washington higher-ups are about convinced that they should tell the world more precise production figures, for this should scare our enemies and be helpful propaganda.

### Cycles and Coats of Mail

*Warfare, ladies' hats and other foibles are ever moving in cycles, often getting back to where they started, prompting some philosopher to say: "There's nothing new under the sun."*

*The most striking illustration has just occurred. Every normal boy was thrilled by stories of charging knights in coats of mail, jousting the hours away. "Egad, Horatio, save thy honor!"*

*In the Battle of Britain, knighthood had returned — knights of Merrie England versus vandal knights jousting in the skies — an event which prompted words that will go down in the archives: "Never before in history were so many lives dependent on so few." They used to ride on chargers — but now with superchargers.*

*Recently the simile became more perfect. Our own American knights are again literally in coats of mail. Pilots wear flak-proof vests composed of overlapping 20 gage steel squares attached to canvas, weighing 13 pounds, able to stop a .45 calibre bullet, discharged at 30 feet.*

*Secrecy surrounds materials and processes used in the mail in King Arthur's time as well as today's. The artificer of metals of yore passed down secrets from father to son. Today it is military secrecy.*

*Anglo-Saxon knights were superior then — and history is consistent!*

In reviewing our production efforts, we must not get inflamed heads concerning our own genius. For instance, emergency alloy steels are modern and we may consider ourselves to have done the best job in their use. But H. G. Batcheller, Steel Div. director, WPB, stated recently that in the use of steels comparable to the American NE, both Britain and Canada are ahead of us.

Use of such steels amounts to approximately 24 per cent of total alloy steel in the U. S., 35 per cent in Britain and 50 per cent in Canada.

#### One Third Our Minerals New

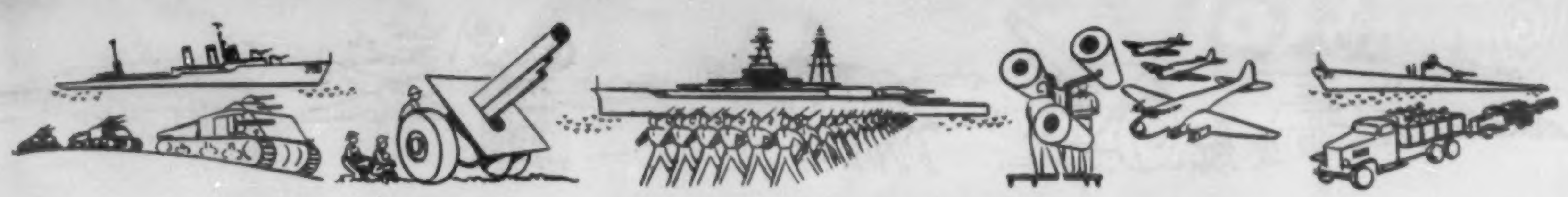
We are using several metals in this war that were scarcely heard of in World War I, points out Prof. C. K. Leith, head of the Metals and Minerals Branch, Office of Production Research and Development, WPB. In fact, a third of our present active minerals and metals were scarcely heard of then. Tantalum for making electronic tubes, and certain varieties of quartz crystals for frequency control of these waves are illustrations.

We are consuming magnesium 370 times faster. From 1914 to 1917 molybdenum was only being experimented with as an alloy of steel, with production now increased 6,000 per cent. Lithium, indium and osmium are used for special secret war purposes.

Dr. Leith also points out that harnessing natural power — coal, oil and water-power — gives each man, woman and child the equivalent of 169 slaves as against 10 in 1890.

Dr. Leith is better known in recent weeks for his theories on "Minerals and Peace." He states that the English-speaking people alone control three-quarters of the world's minerals politically and commercially. The proposal is that the United Nations withhold from any recalcitrant nation supplies necessary to build up armaments to a scale that would menace.

To which we would add a thought of our own — that Germany cannot claim she was a "have-not nation" prior to 1939, else how could she have mustered the world's greatest military machine the world had seen up to that time? Nor did Japan do so badly by herself — though she had perhaps little of basic metallic materials, she knew how to finance and acquire them.



quire them.

Stockpiling of metals is another live topic of the hour — a program which the sponsors would start immediately after this war ends — to be prepared for the next. Some advocate a program over a 10-year period. One interesting suggestion along this line from a consulting engineer friend is that we make ferrosilicon with our western water power at times of slack industry, a material that stores readily and is essential for refining magnesium.

**The Positive Approach: "Presenteeism"**

We have talked of materials. Any new ideas on labor? We heard an industrialist state that in some cases absenteeism is welcomed because plants do not have enough orders to keep them operating full-time anyway — but this is, of course, exceptional.

Western Gear Works, Seattle, Wash., has a new slant — they speak of "presenteeism," using the anode instead of the cathode. During the first three weeks of May, their record was 96.4 as against 95.6 per cent for all of April. Here's a "presentee" record that makes the goose pimples of patriotism stand out on the flesh in the hearing of it. Though her home burned down the day before, Mrs. Emma Willette, tractor driver, G. E. Pittsfield plant, last winter drove 30 miles in weather 40 deg. below zero to be on time.

The "gag" of the month that reached our ears was a statement-made-with-a-smile to the effect that: "Lend-lease will take any *given* amount of war production." But, of course, lend-lease works both ways. The United Kingdom extended to us between July 1, 1942 and April 1, 1943 1,362,681 ships' tons of goods, plus 2,177,384 tons of construction materials.

## 'Tain't the Bark—'Tis the Bite

*by V. M. McConnell*

*Time was when the*
*Hair raising Stuka*
*Unnerved the*
*Non-Aryan palooka;*
*But the shooting iron now*
*That is deadly — and how!*
*Is a little thing,*
*Called the bazooka.*

*(This Yankee steel*
*Forget-me-not*
*Is not so loud,*
*But twice as hot.)*

## Cries of Plate Caution Unfounded

Despite the claim in some quarters to the effect that the unfortunate Carnegie-Illinois incident, involving faked tests of plates, had slowed down plate manufacture because of an era of extreme caution that followed, plate production in May of 1,114,920 tons was not far below the all-time record of March of 1,167,679 tons, comparing with 1,121,647 tons in April.

Production for May 1942 had been 1,012,194 tons.

## Sauce for the Gander Is Ditto for the Goose

The necessity of fitting women to wartime jobs and fitting the jobs to women has brought to the factory progress in production methods and working conditions that may prove a boon in peacetime. Most of the changes made to benefit women are good for the men as well, states the Office of War Information after a survey. Many of the changes were those that intelligent employers were making anyway.

Jobs have been broken down to their component parts so unskilled labor could be utilized. There has been introduction of cranes, hoists and wider use of conveyor belts. The Woman's Bureau says women should not lift 25 lbs. more than 15 times per hr.

Increased attention is devoted to making the job attractive—with better sanitary facilities, medical care, rest rooms and lunch rooms, as well as proper rotation of shifts, safety rules and mechanisms.

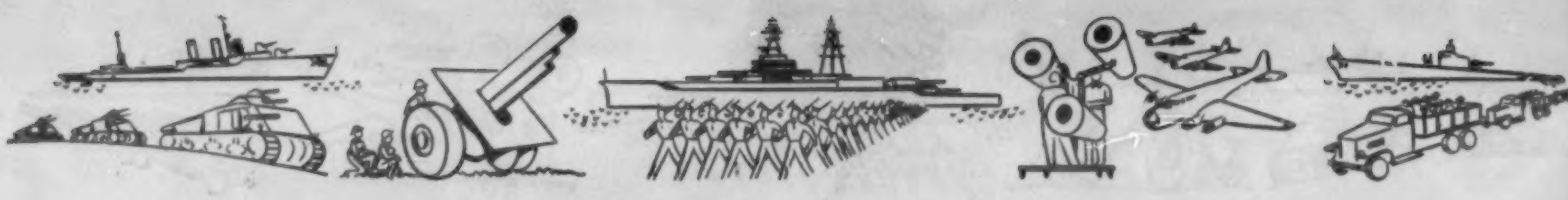
Women demand more maintenance men and porters—but that allows more concentration on production. Most of the changes have tended to speed production. Actually, the average male worker did not absolutely need all the innovations. However, they will keep the male fresher and more rested, all of which promotes better and more intelligent work.

## Scheduling Steel for Battleships

Scheduling of deliveries of war material to fit in with the construction program of a big war item—say an aircraft carrier—causes considerable head-scratching. Large turbine-driven ships, where building-time after keel-laying runs up to 2½ years, should have 12 and, preferably, 20 per cent of their steel delivered at the shipyard before the keel is laid.

Propulsion machinery must be delivered a year before the vessel's completion. Alloy steel parts for the turbine rotor, for instance, must be included in the melting schedules 15 months before the turbines are to be delivered.

So spoke Vice-Admiral S. M. Robinson, U. S. N., at the May 27 meeting of the American Iron and Steel Institute. Castings of ingots for armor must begin two months before the keel is laid. The finished armor is not all delivered until 18 months after keel-laying. Single plates run up to 100 tons and may



remain in a furnace for 45 days.

Machining these great masses to tolerance of $\frac{3}{16}$ in. sometimes takes as much time as forging and treatment. The 14,000-ton presses and giant planers used in making armor may require at least 18 months to build.

## How Our Steel Areas Line Up

Rumored cutbacks in construction of new steel-making capacity are generally denied by Washington and the steel industry, despite the large use of critical materials. More than two-thirds of the $1,500,000,000 program has been completed. This will bring the total U. S. steel capacity to 97,500,000 tons, or more than twice the total output in 1930.

This last 10,000,000 tons of capacity over the estimated total for 1942 is particularly significant because of the disproportionate increase in electric furnace and other alloying capacities, and because the West Coast will become firmly established as a steel producing unit.

The goal for electric steel capacity is about 6,500,000 tons for the nation, as compared with capacities of 422,442 tons in 1925; 801,940 tons in 1930, 942,900 tons in 1935, and 2,365,130 tons in 1940. On a per-ton-of-capacity basis, electric steel facilities are costly.

The West Coast's share of electric steel capacity is 321,000 tons upon the completion of the present program, as compared to its capacity of 35,900 tons in 1940, 22,500 tons in 1935, and only 7,050 tons in 1920.

These new figures of the total steel capacity of the nation's expansion program, subject to revision from time to time, were released by the Government for publication in METALS AND ALLOYS, and appear in the accompanying table.

Thus, it will be seen from the table that the Pacific Coast becomes, roughly, a 10 per cent factor in the nation's steel-making capacity after the war, whereas it had only a negligible capacity in prewar days, although Washington, Oregon, and California account for about 12 per cent of the nation's motor vehicle registrations in peacetime.

The West Coast is getting a wealth of manufacturing experience from plastic parts for gas masks to huge bombers and ships. With copper, aluminum, and other mineral sources nearby and its new refining capacity for minerals, large petroleum developments, and plywood industries, indications point to an industrial revolution of considerable magnitude along the Pacific Coast of the nation—when the coast becomes pacific again.

In Thousands of Net Tons

| Goals For: | Eastern States | Central States* | Southern States | South-western States | Western States | U. S. Totals |
|---|---|---|---|---|---|---|
| Coke | 24,922 | 24,319 | 5,454 | 620 | 2,197 | 57,512 |
| Pig Iron | 31,377 | 30,690 | 5,487 | 663 | 2,946 | 71,163 |
| Open Hearth | 39,919 | 34,798 | 4,774 | 507 | 4,386 | 84,384 |
| Bessemer | 2,054 | 4,499 | .... | ... | .... | 6,553 |
| Electric Steel | 1,952 | 3,865 | 243 | 22 | 321 | 6,403 |
| Total Steel Ingots | 43,925 | 43,162 | 5,017 | 529 | 4,707 | 97,340 |

*For the purpose of this compilation, the Central States are composed of Ohio, Michigan, Illinois and Indiana. California and Washington are the main components of the Western States.

*Steel Capacities Goals, by Districts*

## A 200 Per Cent Mistake

The new Canadian 5-cent piece is gold in color and is made of *six* metals, states *Foreign Commerce Weekly,* published by the Department of Commerce, Washington, which goes on to say that the alloy is known as "Tombac," from the Malay "Tombaga," used in imitation gold jewelry in the East Indies.

This "six metals" interested us and made us suspicious, so we wrote to the Royal Canadian Mint, Ottawa, receiving a supply from A. P. Ward, master of the mint. He wrote:

"The Tombac 5-cent coin is composed of *two* metals, copper and zinc, in a proportion of 88 and 12 per cent, respectively. They were used with the object of further use for coinage as bronze (brass?) when withdrawn from circulation after the war and the nickel 5-cent coin again issued. The metals were used 88-12 to make the coin distinguishable by colour and shape from the bronze 1-cent coin."

It will be recalled that the United States' Mint fumbled around considerably in designing our new 5-cent piece, finally deciding on silver, copper and manganese.


## Open-Hearth Alloy Steel

A trend has developed in the alloy steel industry which some regard as definite and important. In the early days of the war the demand for alloy steels became so great that steel men were consulted as to whether any relief could be afforded by the use of open-hearth furnaces. It was thought that some of these much needed alloy steels could be made in such furnaces thus relieving the pressure on the electrics.

Since that time, it is reliably reported, there has been a transfer of more and more high nickel armor plate steel from manufacture in electric to production in open-hearth furnaces. It is believed that a substantial proportion of this tonnage is now being made of open-hearth steel.

The growing scarcity of nickel forced the War Production Board later to demand other types of alloy steels, which has led to the development of a great variety of steels, usually low in nickel, such as the N.E. and other steels, which are now being made in open-hearth furnaces.

To what extent these developments in the alloy steel industry have spread and what the tonnages are, we do not know. A canvass of the industry would be necessary to answer this question. But that the trend is definite seems conclusive. One authority expresses the opinion that such steels will never again be made in electric furnaces.

The foregoing is but one of the many reallocations that are the results of the war, as are many other changes in metallurgy and metallurgical engineering practice. The story of these will make interesting reading when the "lid is off." —E. F. C.

## No Coasting!

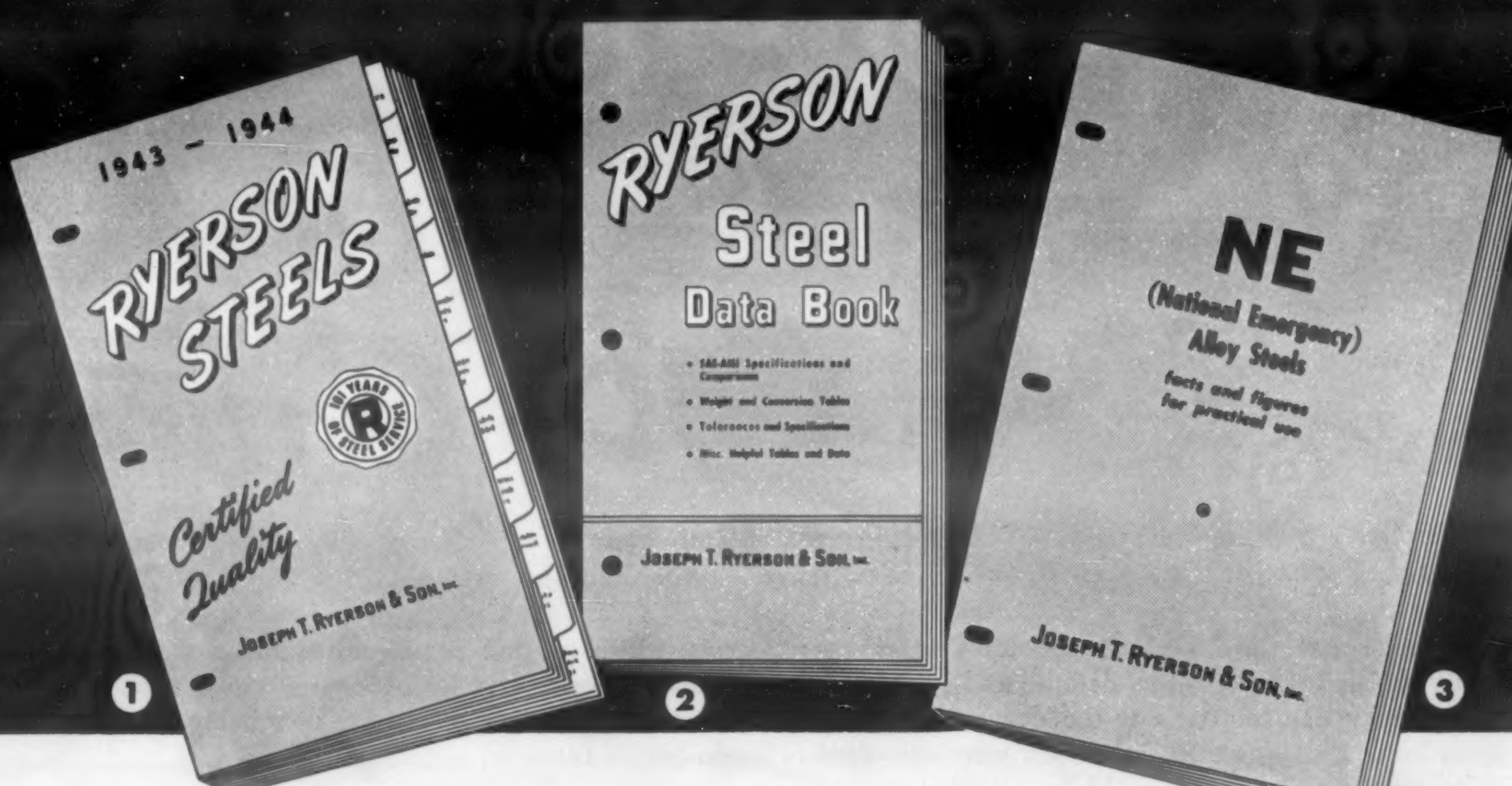
During the last few months there has arisen in this land a strange, insidious psychosis—the tacit assumption that most of the munitions we need have been made and that it is only a question of time now before the enemy capitulates and we can start designing and manufacturing all the wonderful new products of the post-war world.

This idea that we can now coast through to Victory has been fostered by the bright newspaper headlines of the last few months and by contract cancellations in certain lines. The resultant inferences that the major job is done—militarily or production-wise—are not only illogical but potentially disastrous and tragic as well.

# STEEL USER'S

# "Four Foot Shelf"

## Complete Information on Ryerson Stocks in Four Handy Volumes





**1. RYERSON STOCK LIST — BUYING GUIDE OF THE INDUSTRY**
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**DATA AND STOCK LIST OF AIRCRAFT ALLOYS**
Manufacturers and sub-contractors building aircraft parts will be interested in this special information on Alloy Steels listed for quick reference. It also includes summary specifications of the AMS and the AN-S specifications.

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# RYERSON STEEL-SERVICE

In the first place we have yet [June 17th] to undertake an engagement on anything approaching the scale of the German-Russian battles. The *real* shooting war hasn't begun for America. The conquest of Nazi Europe alone will require the destruction of a still-powerful enemy army of 8-12 million men defending its homeland and with ever-shortening internal communication lines. And after that we'll need plenty of extra munitions and time to deflate and destroy the Japanese.

Production-wise it is absurd to consider the task as anything else but just getting underway. Contract cancellations and program cutbacks have occurred in certain lines—tanks, for example—but for entirely strategic reasons. The military emphasis has shifted from tanks to mobile artillery and ammunition, from small bombs to blockbusters. And cutbacks in one program are more than offset by increases in another. True, a large part of the construction and tooling programs are completed, but *thousands* of machine tools are still needed and the general backlog of orders for such equipment is now about 5 months and for 100,000 machines.

The curve of production requirements is still rising steeply. This year we must double our number-of-planes output and triple the aircraft tonnage over 1942. In ships the drive to increase tonnage continues. The steel industry will be expected to produce an extra million ingot tons in the third quarter and still another extra million in the fourth. *WPB's over-all war-production goal is 50 per cent more in the last six months of this year than in the first. Does that sound as though the pressure is off?*

On the contrary the pressure should be on harder than ever. We're off to a marvelous start, and if we maintain our present acceleration we *can* shorten the war by weeks or months. To do, say or plan anything that may involve even the smallest relaxation of production and engineering effort will, on the other hand, prolong the struggle tragically.

Remember there are several hundred American families that lost a son, brother or father each because World War I ended on Nov. 11 instead of Nov. 10, 1918. Multiply that one day by all the extra days that coasting now can cost us, and you'll agree that the word "tragically" above is no overstatement.

—F.P.P.

## For Production Excellence

One of this war's unsung heroes is the process engineer. Few people indeed realize the magnitude of the task accomplished by the men who "broke down" into single operations the construction of such precise and complicated engines of war as planes, tanks and guns, or the smaller but no less precise pieces of equipment—radio tubes, time fuzes, optical instruments, and many thousands of others.

The war had created the problem to produce unprecedented quantities of this equipment with unskilled and untried workers, often women who had never seen the inside of a factory. The process engineer, the production engineer, the methods and the tool engineer provided the answer in simplified operations performed with complicated machines.

In many cases new plants were needed to produce these weapons. Engineers broke down the finished article from blueprints, laid out subassemblies, individual pieces, separate operations, routed the pieces through plants not yet built, selected machines, and designed tools, jigs and fixtures to simplify operations where possible. Huge plants were built to house the processes and machinery. The American armament program, jeered at as fantastic by our enemies, got under way.

Due to many causes, there had been all too few real mechanics in the United States even before the war program was started. The requirements of the armed forces thinned these ranks, and the manpower problem became of first importance. Then something happened. Manicurists became machinists, washerwomen became welders, stenographers became ship builders—and the newspapers wrote columns and published pictures about women solving the manpower problem.

The real solution of the manpower problem, insofar as it dealt with replacing the skills of the experienced mechanic called into the armed forces, came from the engineer. Processes and machinery were so simplified that even precision work could be performed by girls who didn't know the names of the jobs they were doing. What little mechanical skill was still available was hoarded by the use of set-up men or subforemen. Jigs, fixtures, special tools or even special machines reduced the skill of the mechanic to that of the machine feeder. Welding, forming, and stamping machines simplified and mechanized much of our fabrication. This process, which had been going along steadily before the war, was accelerated by war needs to the proportions of a small industrial revolution.

All due credit to the woman war worker. She has done a great job. But a quiet little "Thank you" is due the engineer who provided much of the inanimate skill for the change-over. —K. R.

*(Editorials continued on page 70)*

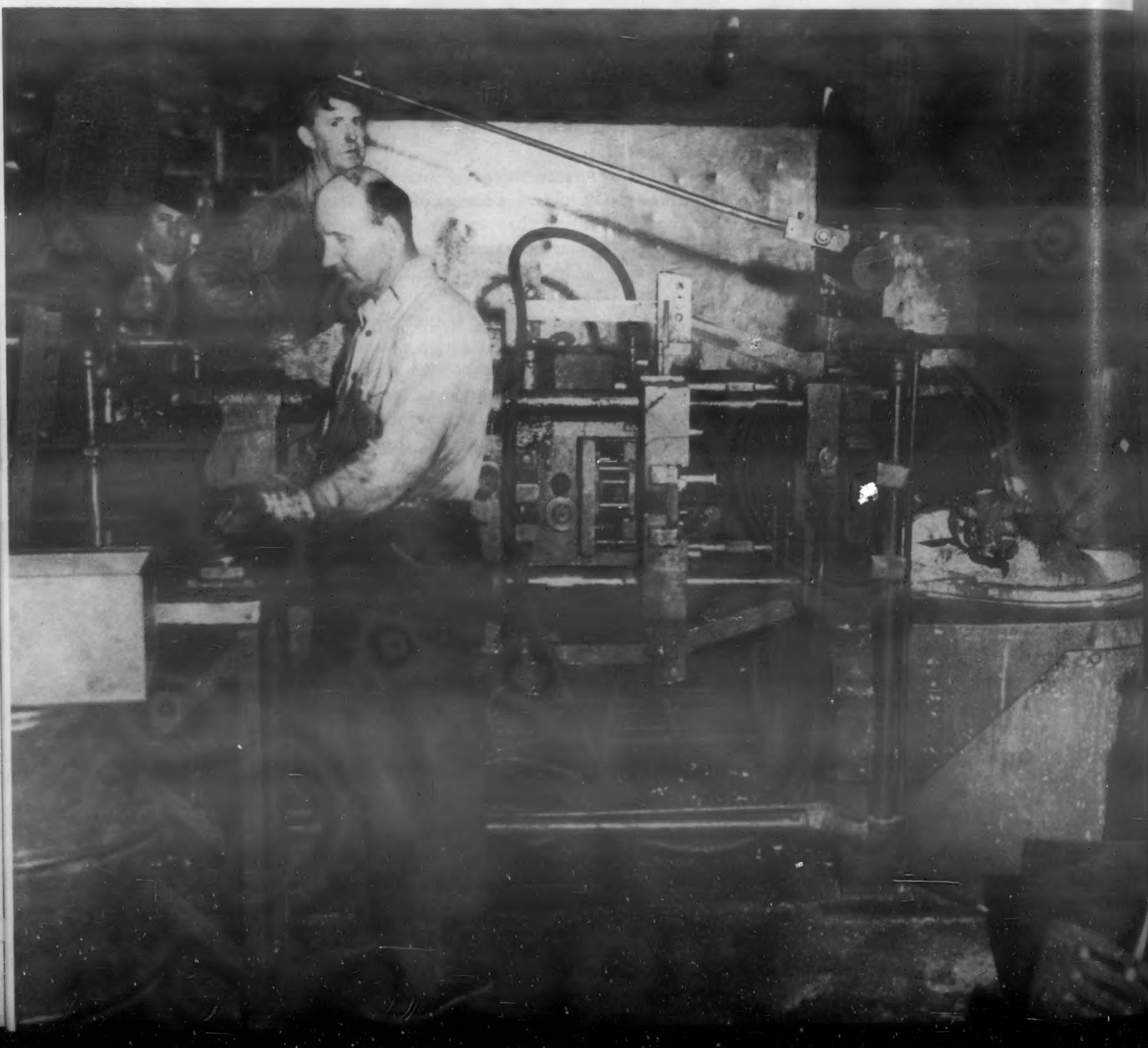
# Die Castings for the War Effort

**by GUSTAV NYSELIUS**

*President, Mount Vernon Die Casting Corp., Mount Vernon, N. Y.*

*American engineers familiar with the design and production advantages of die castings have been dismayed by the general failure to accord die castings their rightful place in the war program. To some extent an inadvertent obstruction has been too-rigid specifications on the use of zinc die castings for ordnance parts (as will be demonstrated in a subsequent article describing the extent to which zinc die castings are applied in Canadian ordnance). Therefore a few progressive die casters, still making as many high-priority zinc die castings as possible, have in addition radically modified their plant and equipment to permit increased production of aluminum aircraft parts, with considerable aid to our overall war effort. This article is the case history of one such plant, and is published to stimulate other die casters to emulate it.* —*The Editors*

*Type of gooseneck machine for casting aluminum now being discontinued. The gooseneck itself is partly submerged in molten alloy in the metal pot at right. This machine accommodates two unit dies, one of which casts a part with a male thread formed by a block with a female thread. A pair of these blocks is provided and one block is removed and the part unscrewed, by the man in the foreground while the second block is used.*



FEW TYPES OF JOB SHOPS, geared to serve the metal working industry with high production items, were so hard hit by transitions to war work as those specializing in die castings. Most such plants did the bulk of their work in zinc alloys and zinc soon became scarce, largely because of the heavy demand for brass, especially the type for drawing into shell cases. Army and Navy specifications for zinc die castings greatly limited their use for war products although England and Canada found the zinc die castings exceedingly useful.

Aluminum alloys, next in importance to the zinc alloys for die castings, also became scarce and aircraft manufacturers, though somewhat acquainted with die castings, especially of the aluminum and magnesium types, had not learned to take full advantage of their possibilities. Specifications bearing upon porosity and iron content in aluminum die castings proved hard to meet, especially with the gooseneck type of die casting machine which is commonly operated at 450 lbs. per sq. in. or lower pressures.

The number of cold-chamber die casting machines (which operate, as a rule, at 6,000 lbs. per sq. in. or higher pressures) was limited and their rate of operation was rather slow. These and other factors proved so great a handicap to a large proportion of die casters that their business fell, in most cases, to a small fraction of their pre-war capacity.

There are some exceptions to this rule, one of them being the Mount Vernon Die Casting Corp., Mount Vernon, N. Y. Its executives foresaw the war trend and prepared so well to meet it that the capacity of its plant has been nearly doubled. Some 80 per cent of its current business is for the aircraft industry today, though it had relatively little of that business before the war. Because the aircraft product puts a premium on light weight, equipment for making aluminum die castings was greatly increased, but the zinc die casting has kept very much in the picture, as numerous war uses were found and met. Die cast zinc parts for machine tools, instruments and many other products have continued and in some products, where aluminum was used before, zinc has taken its place and serves the same purpose.

In general, aluminum was continued only or chiefly where light weight was essential. Where the product made is air-borne, aluminum has the call but, if a ground or naval use is involved and minimum weight is not a factor, the zinc die casting is usually specified. Some companies served have dies which are used for aluminum where light weight is demanded and for zinc when it is not needed.

## Cold-Chamber Machines for Aluminum

The initial expansion for making aluminum die castings was with gooseneck machines, but several factors have made a rapid shift to the cold-chamber high pressure type necessary. These may be summarized as follows: The high pressure, applied by hydraulic means, results in denser castings. Aluminum does not come in contact with cast iron, is not subjected to the extreme washing effects which take place in an iron gooseneck, and its contact with steel, while still molten, is very short. In consequence, iron pick-up is slight.

These are highly important factors in die cast parts for aircraft applications. They help greatly in meeting rigid specifications. In consequence, rejects, which are likely to be high with gooseneck machines, are greatly reduced.

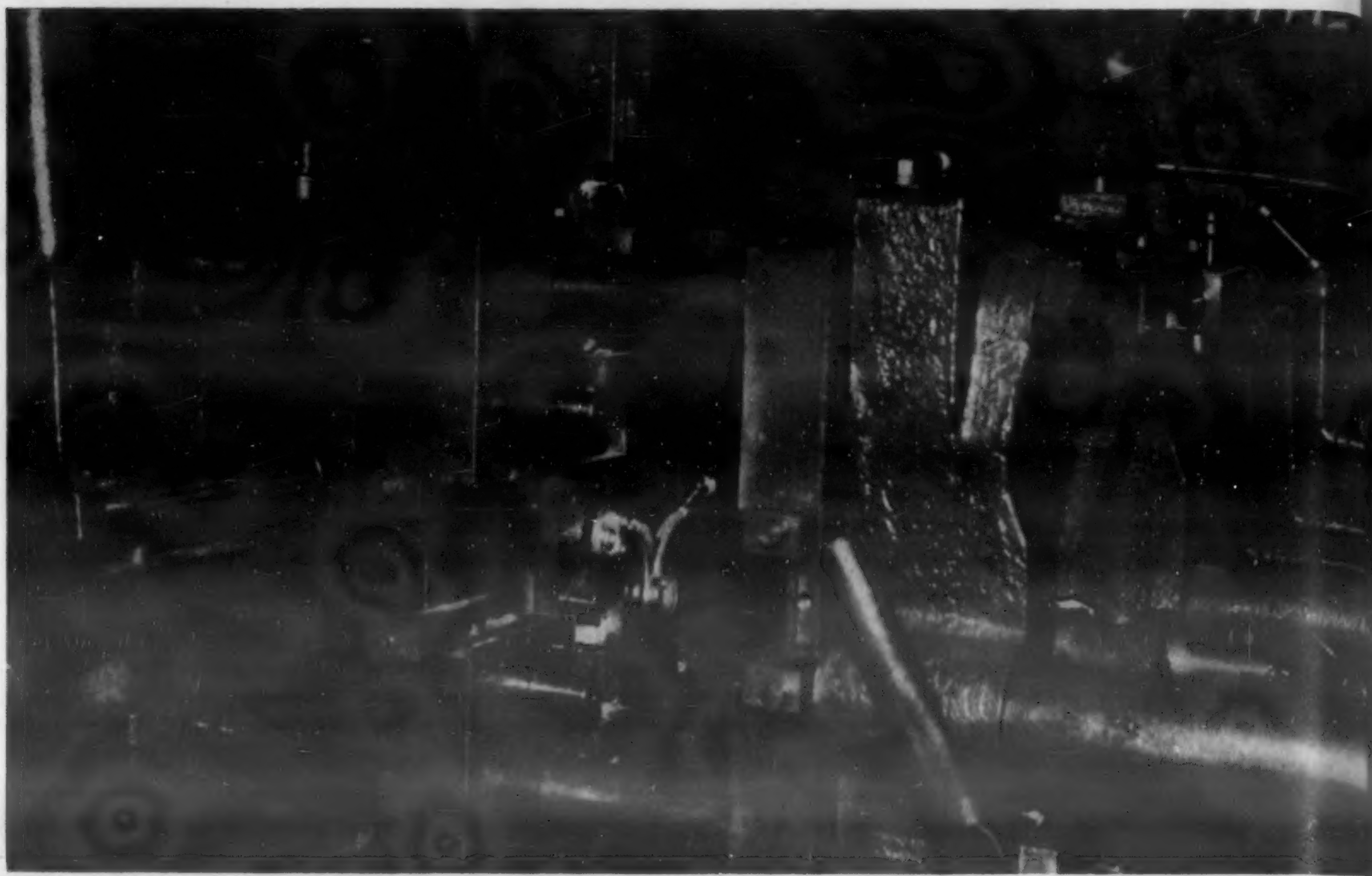
In the case of the gooseneck machine, the gooseneck may last 2 to 3 weeks and costs about $40 to replace, not allowing for down time and replacement labor. Nozzles last 2 to 8 hrs. and cost $1.50. A metal pot may last 4 months and costs about $40 to replace without labor and down time losses. Moreover, it is hard to secure good iron castings for such parts. So the gooseneck machine is rapidly going out.

The Mount Vernon Company is retaining the die-operating end of these machines and is replacing the gooseneck and nozzle with cold chamber parts: A hydraulic cylinder, ram and injection cylinder. A new and entirely separate metal pot and furnace, so made as to keep the aluminum out of contact with iron except while being ladled and injected, is provided.

*Two gates and some of the separate parts cast in a pair of unit dies in machine shown in first photograph. One of the removable die blocks, which has a female thread, is shown in the foreground. At the left is the special spanner used for unscrewing this part.*

Although hand ladling and other operation factors make for a somewhat lower casting rate, this is offset by better castings and fewer rejects. More hydraulic equipment, operating at high pressures, is required, but the use of separate pumps for each machine, shortly to be installed, is expected to lower power costs and avoid the less economical operation of a central system now in use. A primary gain, however, is in the better castings produced and the great reduction in rejects.

Another improvement recently added is an X-ray machine for viewing, photographing and inspect-



*Looking into the open dies of a cold-chamber machine using two unit dies. A gate of two castings is about to be ejected. The bent bar at the top is for operating a core or slide. Valve near top right corner is for returning the injection ram and the lever beside it controls the valve (not shown) for advancing ram when shot is made.*

*The injection end of a cold-chamber machine. At the left is the hydraulic cylinder for operating the ram and back of the cylinder is the furnace from which metal is ladled. In this set-up, this machine fills two dies 75 times per hr.*

ing castings. It makes possible the location of porous spots and becomes an exceedingly helpful guide in making changes in die construction to either eliminate porous spots or relegate them to parts of the casting where they have no detrimental effect. Formerly, this was done by the slow process of cutting up castings to locate the porous areas and never being sure that they were all revealed even then. Although this is not an entirely new departure in die casting practice, few die casting shops have had X-ray equipment until very recently. Today, some requirements, especially for aircraft parts, make it necessary to X-ray 5 per cent of the castings produced. Once the die is right and operating conditions are stabilized, however, the proportion of defective castings produced on cold chamber machines by experienced operators is small.

## Die Cast Alloys and Parts

At present, Mount Vernon is employing three aluminum die casting alloys. These are covered by Army specification QQA-591, Classes 1, 5 and 7. They correspond, respectively, with Alcoa Nos. 13, 85 and 218. The Zamak No. 3 zinc alloy is somewhat stronger and has much higher impact strength than the best of the aluminum die casting alloys but weighs almost 2.5 times as much. For this reason,

it is little used in aircraft parts, although it goes into many parts for aircraft ground equipment.

As the zinc alloys for die casting do not attack iron or steel to a significant extent and cast at a relatively low temperature, they have long been cast in plunger type machines in which the injection cylinder remains in continuous contact with the molten zinc. For this reason, and others, casting rates are usually two to three or more times as fast as for the aluminum machines, making, of course for lower casting costs. Die also last much longer than with the aluminum alloys.

Among the aluminum alloy parts now in active production by Mount Vernon are the following aircraft parts: Electric generator and starter end frames and control parts, bomb releases, ignition switch parts, de-icer parts, automatic pilot parts, motion picture camera parts, compasses and other aircraft instrument parts, radio components, lighting equipment, windshield wipers and control elements.

Zinc alloy parts classed as aircraft but chiefly for ground installations include: Numerous Link trainer parts, radio and lighting equipment, certain items of electrical equipment for aircraft carriers, electric generator parts and parts for fire control and life raft inflation. These are in addition to numerous non-aircraft uses, including marine, instrument and machine tool parts having high priority ratings. A considerable number of parts used in Army tanks are also produced.

## Unit Dies

For small to medium size parts, Mount Vernon has long specialized in the use of so called "unit" dies. This application is now extended to several cold-chamber machines. Unit dies are made in standard sizes to fit into a chase or holder which accommodates either one or two dies in cold chamber machines or either 2 or 4 dies in other machines. These are connected to a common sprue hole and are filled simultaneously.

Since many dies have two or more impressions, several castings are often produced at a single shot of the machines. As many as 24 castings per shot have been made in some of the zinc machines, which are the only ones as yet equipped with 4-die holders. These, as well as the 2-die setups, have means for automatic core operation and the zinc machines have automatic ejection, though the gate of castings is removed by hand.

Operation of the cold-chamber machines, for aluminum, is hydraulic except that, for die locking, toggles are interposed between the hydraulic cylinder and the movable platen. Water at 375 psi. pressure is used for toggle operating cylinders, but for the injection ram there is an oil cylinder operating from a 1000-lb. line. The ram itself is of 2-in. diam., but the hydraulic actuating plunger has a six times larger area so that 6,000 psi. pressure is applied to the metal injected.

*These aluminum alloy die castings are produced in a cold-chamber machine. The cylindrical parts are metal slugs left at the end of the ram when injection is complete. Runners and overflow wells are seen around the periphery of the piece which is a generator end frame in No. 218 alloy.*

*Looking into the die which casts the part shown in the preceding photograph. End of injection ram is seen at left and the casting, which has been ejected from the cavity in the movable half of the die, is at the right.*

*Closeup of zinc die casting machine that handles 4-unit dies simultaneously. A gate of castings is being removed. In this machine, the injection ram is vertical and operates in a cylinder inside the metal pot. Ingots of zinc alloy are seen in the lower right corner.*

As with all cold-chamber machines, the aluminum is ladled into the plunger cylinder by hand. In all cases, somewhat more metal is added than is needed to fill the die. This leaves a slug opposite the ram in the die, corresponding more or less to the sprue in other types of machines. Although some experiments were made with an air-operated plunger, it was found that the somewhat slower operation when using a hydraulically operated ram resulted in sounder castings. This apparently is because there is more time for air to escape from the die.

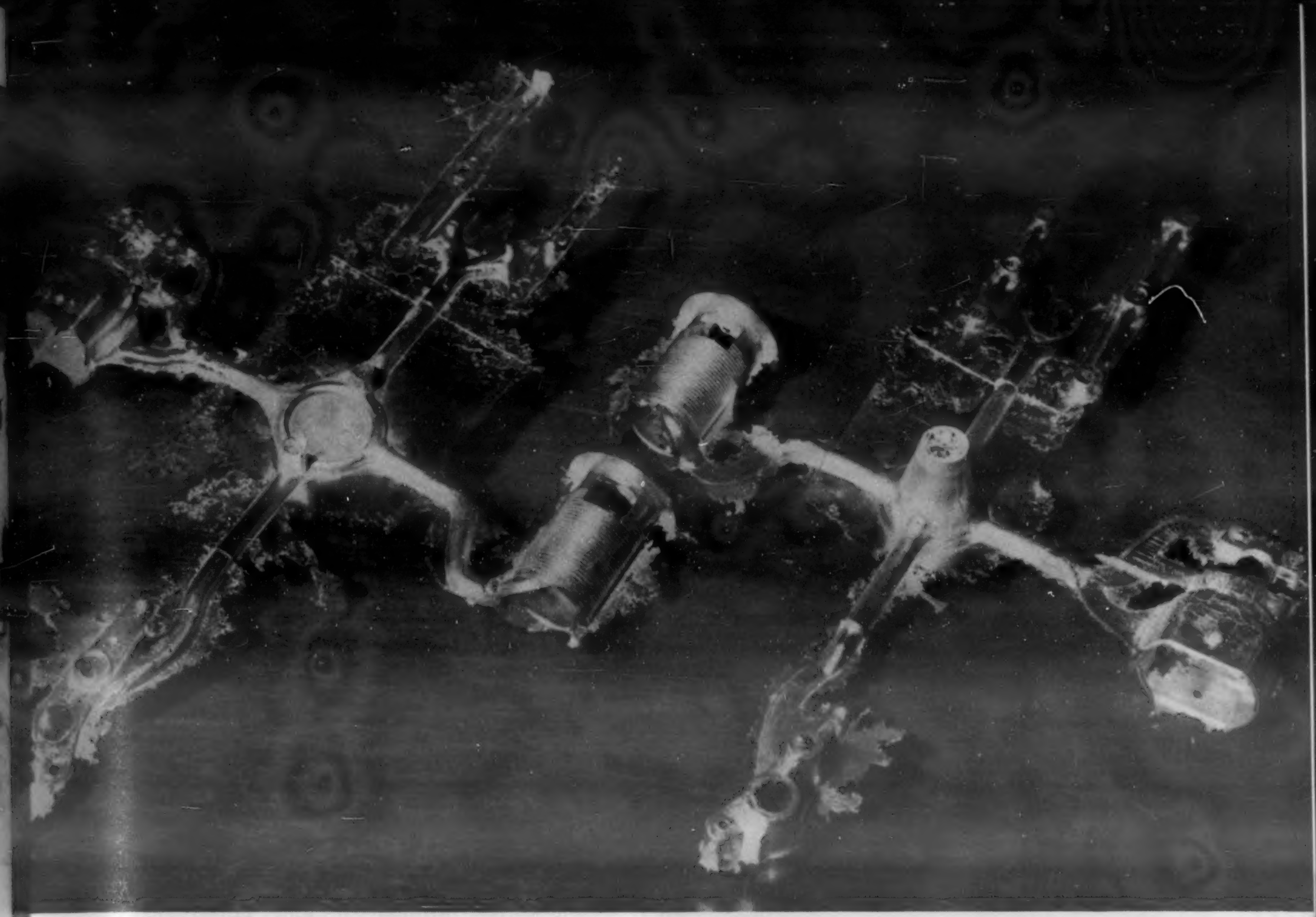
When dies larger than those which can be accommodated in holders for unit dies are needed, the work is done on single-die machines. These are similar to the multiple-die type, but use hand-operated ejectors and some cores have to be operated by hand levers. It is still possible, however, to run at an economical rate, although it is lower than for unit dies filled in multiple.

Not all the gooseneck machines have been replaced as yet and those still in use produce castings satisfactory for many purposes. As the pressure applied to the metal is about 525 psi., it does not require so great a die locking pressure, of course, as for the cold-chamber machines operating with 6,000 psi. on the metal. This means that, for a machine with a given locking pressure, a much larger die can be used for the 525-psi. air injection than for cold-chamber work at much higher pressure.

For gooseneck machines, about the maximum casting rate is 110 shots (die fillings) per hour. To date, 90 shots an hour is about the maximum attained with cold-chamber machines, partly because of the hand ladling of metal required. There is, however, the offsetting advantages of a much higher proportion of sound castings and of lower maintenance, as already explained.

## Types of Machines Used

Accompanying illustrations give a good idea as to the types of machines used and the character of work done in this plant. As a rule, the gates of castings are laid on steel benches as they are removed from the machines and are pushed along the benches as they cool. At the end of each bench a helper usually breaks the castings from the gate and places them in tote boxes for transfer to machines where flash is removed and any machining specified



*Both sides of two gates, each comprising six separate zinc alloy castings made in 4-unit dies in machine shown in preceding photograph; 1800 to 2000 such gates are produced in 8 hrs. The cores are all pulled automatically. The die that forms the part at the extreme right and left has also been used in an aluminum machine and shows heat checks resulting from the higher temperature at which aluminum is cast.*

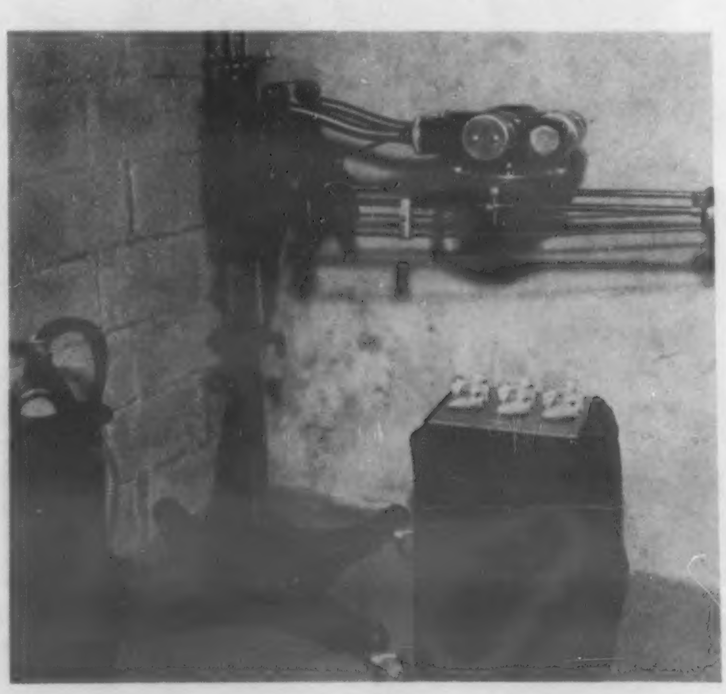
is done. Gates are thrown into other containers and are shifted back to the metal pot for remelting at the same machine.

This helps to keep alloys separate, especially where adjacent machines are using different alloys. Formerly a conveyor paralleling the rows of machines was used to carry sprues and rejects to a common melting point, but the current demand for three different aluminum alloys, usually being run simultaneously, has made this arrangement obsolete for the present.

The aluminum machines and the zinc machines are kept in different departments and scrap is naturally kept separate. New aluminum ingots are being purchased ready alloyed and suitably marked for identification. They are delivered to machines and stacked next to the furnaces where machine operators add new ingots, as well as sprues from the same run, as needed.

Wherever feasible, flash removal is done with shaving dies in punch or kick presses, some small parts being trimmed in multiple. In many instances, however, flash removal has to be done in drill presses, light lathes or even in hand milling machines. Although an effort is made to minimize hand work, rigid aircraft specifications make it necessary to do much hand filing and burring. Belt sanders are also used effectively in some types of work.

*An X-ray machine set up for radiographing three die castings. When no negative is required, machine and castings are shifted to fluoroscope window in wall of chamber, for visual examination of castings. The machine is used both in routine inspection and as a guide in altering dies to yield castings which are free of porosity in critical areas.*



# Valves Repaired by Electric Welding

**By EVERETT E. KERNS**

*Mechanical Engineer, Inspection Div., Standard Oil Co., Cleveland*

*New valves — especially alloy and stainless steel valves — are among the equipment components most difficult to obtain at present. The repair of worn and corroded valves wherever possible is therefore indicated. In this article — an award winner in the James F. Lincoln Arc Welding Foundation's recent $200,000 prize competition — the engineering design and welding practice for successful valve repair are outlined.* —*The Editors*

*Some spectacular effects in certain welding operations. (Courtesy: Lincoln Electric Co.)*

THE REFINING OF OIL has developed into one of the largest industries of this age. From the discovery of the first oil well, valves have played an important part in production, transportation, refining and marketing. From the time of the producing of the first oil in Pennsylvania there have been hundreds of other fields discovered throughout the world. Today with the vast amount of production, oils from the many fields have varied characteristics. One of the characteristics that faces the refining division is corrosion, which costs this division millions of dollars annually. As the oils from the many fields vary widely, so the corrosion rates differ during the processing period.

With the development of the refining processes there has been a gradual increase in both temperature and pressure, until today temperatures of 1000 deg. F. and pressures of 1500 lbs. per sq. in. are quite common. Along with these increases have been higher feed rates accompanied by improved fractionation. The higher feed rates have resulted in greater velocities which present another problem, namely, erosion. So when the oil refiner was faced with the problems of corrosion and erosion throughout the various stages of the refining process, he soon found that cast iron valves had to be replaced with steel, and then certain parts of steel valves had to be of stainless material.

The use of alloy materials in valves began with the installation of stainless steel trim. In the case of gate valves, which are the subject of this article, stainless steel trim represents the gate, seats and stem. When these parts are of solid stainless steel materials, they resist corrosion and erosion very well. Then came the corrosion problem on the face of the flanges to the ring joint gasket, and corrosion and erosion in the body of the valve, including run-of-the-body and bonnet section. It is in these locations that electric welding has played a very important part.

## Metal Thickness of Valve Bodies

Definite limits have been established by inspection departments for metal thicknesses of valve bodies for the various service conditions. When these thick-

nesses are reached, the inspector condemns the valve and a new one is installed. In recent years this practice has become almost a thing of the past. Now the valve is removed from service just before the metal thickness reaches the condemning stage and is sent to the machine shop where the machinist takes a light cut from the run-of-the-body to smooth the surface. A machine cut is also made on the faces of the flanges from the port out beyond the gasket groove.

With these operations completed, the valve body is sent to the welding department where a tube of stainless steel material, either 11 to 13 per cent Cr or 18-8 chromium-nickel, is inserted in each end of the run-of-way. These tubes extend to within 1/8 in. of the back side of the seats and flush with the faces of the flanges at the other ends. The electric welder then welds the outer end of these tubes to the valve body with stainless steel electrodes of 25-50 chromium-nickel. The alloy deposit is carried out over the face of the flange beyond the outer edge of the gasket surface. This portion of the flange is built up with deposit weld metal to a depth of some 1/8 in. higher than the original face of the flange.

Due to the non-uniformity of the bonnet section of the valve, it is rather difficult to install any kind of sheet lining material, so here the welder proceeds to deposit-weld the stainless steel wire over the entire surface, extending all the way from the edge of the bonnet flange to the top of the seats. This deposit is also of 25 to 20 chromium-nickel and will approximate 3/32 in. in thickness. A thicker deposit is necessary in the guide sections which serve to keep the gate in position during its travel.

Oftentimes when new seats and gates are not available, they are also given a light machine cut and are then built up with alloy deposit metal and remachined.

## Advantages of a High Alloy Rod

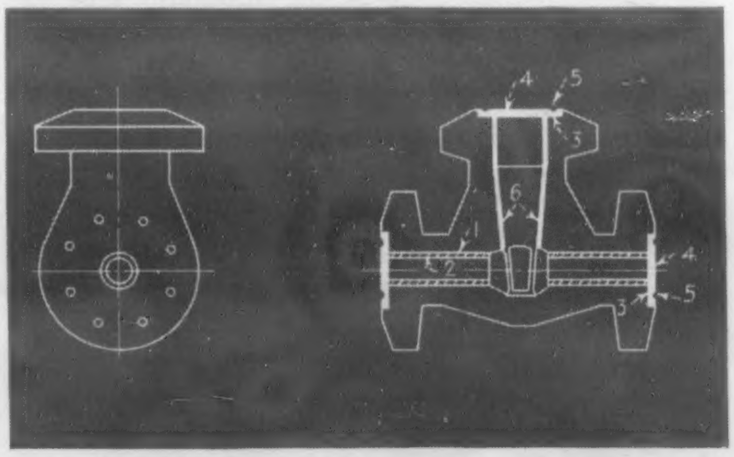
About a year ago we began using the 25-20 chromium-nickel electrode which has advantages over the 18-8 rod formerly used. The greater ductility of the higher alloy rod and the improved machining qualities make this alloy much superior. No failures of the welds resulting from stresses have occurred during this period. The best type of workmanship results from machining this ductile weld metal, which makes a smooth surface for the gasket, and thereby reduces any possibility of leakage.

After the welding operation, the valve body is returned to the machine shop where the faces of the flanges are machined to the original dimensions. This completes the operation and gives us a carbon steel valve completely lined or protected with corrosion resistant material which is good for years of service. Five or six years ago this same valve body would have been sold for junk and replaced by a new valve of the same material costing about $300 for a 4-in. size. The cost of lining will average about 25 per cent of the cost of a new valve, and when considering the thousands of dollars invested in such valves, the remaining 75 per cent represents savings running into large figures.

These savings are not only measured by the difference between the repair costs and the value of a new valve, but also by the saving in operating costs. Such repairs can be made within a three-day period, and in normal times the delivery of a new valve would take much longer. When considering the loss of production by not having a valve ready for installation at the right time, we are again speaking in terms of thousands of dollars. Today, this is a far more important item since deliveries are in terms of months instead of weeks.

Another item worthy of consideration is the saving from a maintenance standpoint. A record is kept of the location of all lined valves, and where formerly the valves had to be taken apart at 30-day intervals for inspection purposes, now a lined valve may be installed and left in service for periods of six months or longer with no maintenance cost whatever. We have a number of lined valves that have been in constant service for 5 yrs. and have required no maintenance except for disassembling at infrequent inspection periods. This item alone aids materially in reducing the "off time," thereby returning the unit to operation with a minimum loss of time.

We have the welding industry to thank for the development of the finest electrodes and well designed welding machines, making it possible for the refining division of the oil industry to make repairs to one of the most essential parts of their equipment — valves. There is but little doubt that the same operation, tried before the days of coated electrodes, would have been unsuccessful. Today we are able to buy a number of different kinds of alloys suitable for numerous conditions for doing repair work. All of this results in a reduction of our maintenance and hence operating costs, thereby saving the oil industry many thousands of dollars annually.




*Alloy liner for 4-in. forged steel gate valve. (1) Bore inside of valve run-of-way to "true up" the surface. (2) Alloy steel of 11 to 13 per cent Cr or 18-8 pressed tightly in place to within 1/8 in. of seat rings. (3) Machine face of flange for deposit weld metal. (4) Alloy deposit weld metal of 25-20 chromium-nickel. After depositing, the surface is machined to the original dimensions of the flange. (5) Ring joint groove machined in the deposited weld metal. (6) Deposit weld metal 3/32 in. thick — not machined.*

No. 2 in a series on Refrigeration in the Metal Industries

# Sub-Zero Temperatures f

*This article, the second in our series on refrigeration in the metal industries, discusses the methods, types of equipment and other practical aspects of fitting mating metal machine parts by chilling the inside member just before the fit is made. The experience of several users of this technique is presented in detail. The first article — on refrigerated aluminum alloy rivets and parts — appeared in our June issue. Others will follow.* —*The Editors*

**By HAROLD A. KNIGHT**

*News Editor*

ONE OF THE SIMPLEST applications of sub-zero chilling equipment is the contracting of a metal part so that it will fit into some opening during its contracted stage. Upon warming, the part naturally resumes its former size and has made a tight fit with its companion part. Here chiefly mechanical change is involved, the process not being regarded as a form of heat treatment to change the grain, either in size or microscopic structure.

Probably the majority of the applications of extreme cold to metals today involves shrink fits. Since coefficients of expansion are standard pieces of knowledge of the engineer, it takes no great skill to determine proper temperatures and procedures.

## Formula for Shrinks

The engineer may figure out in advance how much shrinkage he will attain from a given set of circumstances by referring to tables of coefficients of expansion (which in this instance might be called "coefficients of contraction"). Thus for a sand cast hard bronze (SAE 62) the coefficient is 0.0000097.

For cases of contraction the formula is: $L_2 = L_1 (1 - CT)$. $L_2$ represents the new dimension resulting from the application of cold; $L_1$, the original dimension; C, the "coefficient of contraction"; and T, the complete range of temperature through which the treated part passes. Let us assume that this sand cast hard bronze (SAE 62) bushing has an outside diam. of 2.000 in. and that in the process it is brought down from 70 deg. F. to —40 deg. Hence the formula works out:

$$L_2 = 2.000 \text{ in. } (1 - [0.0000097 \times 110]$$

Therefore, $L_2 = 1.998$ in., shrinkage having been the difference between $L_1$ and $L_2$, or 0.002 in. [This and the tables herewith were adapted from No. 9, "Engineering File Facts," METALS AND ALLOYS, April, 1943.]

The table gives coefficients of linear expansions (hence contraction) for some of the more common metals:

*Table of Coefficients of Linear Expansion*

| Material | Condition | Coefficient of Expansion |
|---|---|---|
| Aluminum alloy: | | |
| No. 112 SAE 33 | Sand cast | 0.0000122 |
| Copper alloy: | | |
| Yellow brass, SAE 41 | Sand cast | 0.0000106 |
| Gray iron: | | |
| SAE 110 | Sand cast | 0.0000062 |
| Malleable iron | Malleableized | 0.0000066 |
| Magnesium alloy: | | |
| SAE 50 | Sand cast | 0.0000015 |
| Monel B | Wrought | 0.0000078 |
| Steel, SAE 1020 | Annealed bar | 0.0000065 |

The sub-zero shrink fit technique is quite the opposite of the general methods formerly used. Instead of shrinking one part, the mated part was usually *heated* to effect an expansion. However, this heating often distorted the piece by warping or other malformations and sometimes previous heat treatment was partially or wholly undone. Or again, the surface was often decarburized. In many instances pressure was used immediately following the heat expansion, and this resulted in burrs, marks, or other distortions and blemishes. A compromise plan was to chill one part and heat slightly another part, while the third plan is, of course, merely to chill one part, leaving the other at room temperature.

## Advantages Over Press Fits

Shrink fitting of inserts has many advantages. As compared with press fits it avoids the necessity for using press equipment, which in the case of large bushings would have to be quite ponderous and might be unavailable. With press fits both the insert and the body are subject to scoring, which is avoided by shrink fitting.

Shrink fittings are subject to almost uniform compression developed as the inserts expand while they heat up to room temperature. The resultant assembly remains tight and satisfactory under operating conditions involving cyclic stresses, changes of temperature, etc. longer than by any other method of assembly short of sweat soldering or brazing. It is

# for Shrink Fits

predicted that as methods of handling improve and liquefied gases are made more available — oxygen, air and particularly nitrogen — this method of assembly will become increasingly important.

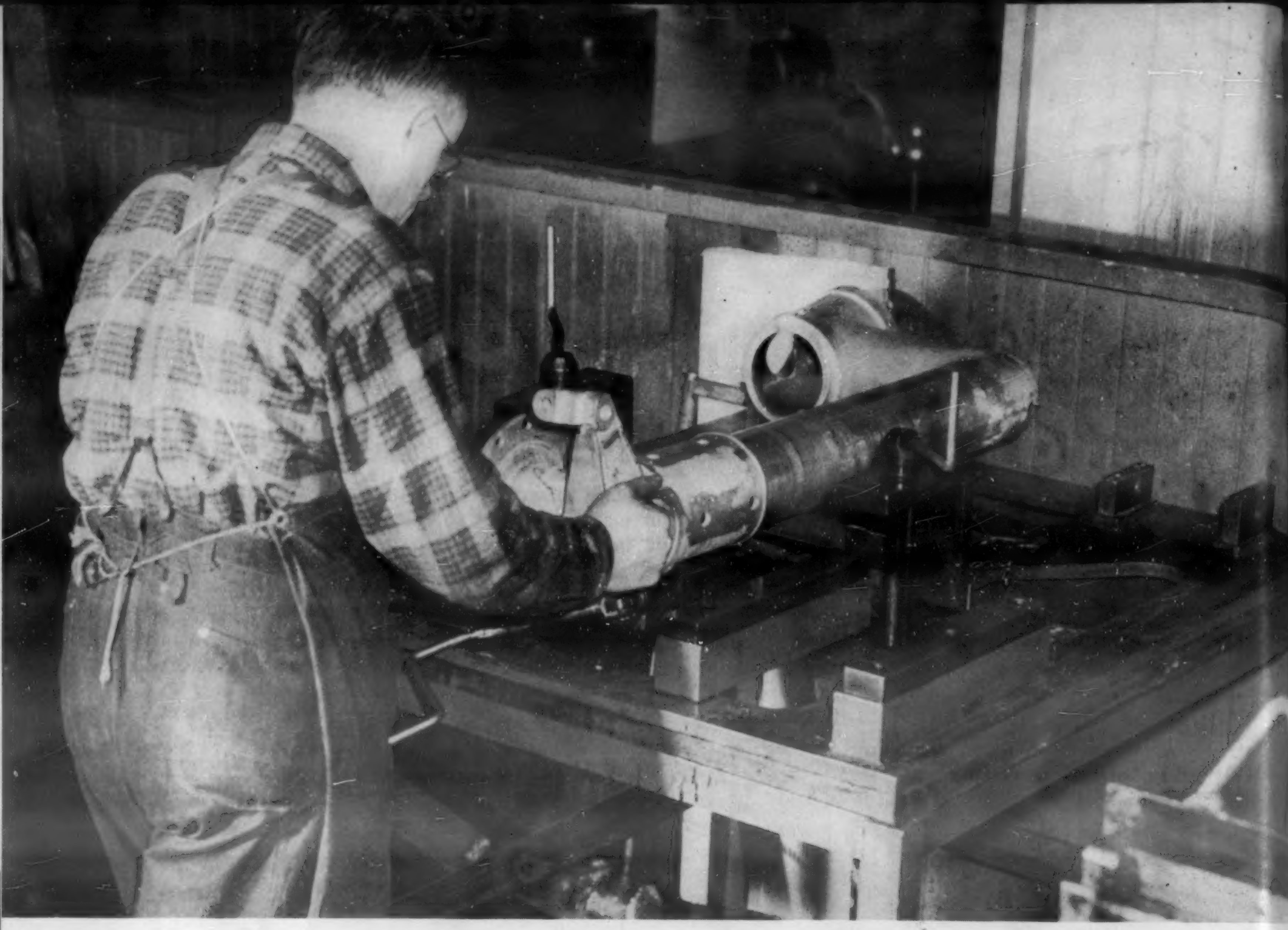
The necessary cooling is obtained by one of four principal means: Mechanical refrigeration, solid carbon dioxide, indirect cooling by liquid air and direct cooling by immersion in liquid air. The recent development of improved mechanical refrigeration units yielding temperatures as low as —120 deg. F. has increased greatly the applicability of this type of refrigeration. The high initial cost of the mechanical refrigerator must be set off against its convenience in continuous operation and long-period costs. Apparently the trend is towards this type.

## Batch and Continuous Processing

Usually shrink fitting is done in batch operations. But machines have been, and are being, developed for continuous processing of small parts used in large numbers. Such machines consist essentially of tubes surrounded by a very low temperature cooling medium, liquid oxygen or liquid air. Parts are inserted in the tubes and pushed through either manually or automatically, insertion of a fresh piece forcing out a finished chilled piece.

Direct immersion in liquid air is needed in some instances where the greatest amount of shrinkage is necessary. Parts must be dry, clean, free from oil, and cool. They must be immersed into the liquid

*Fitting bronze bushings into pistons at the plant of the Ohio Piston Co., Cleveland.*



*Placing the chilled male portion into the companion section of an airplane landing part.*

*Chilling the male part of an airplane landing strut assembly at a war plant.*

air slowly to avoid violent boiling. Parts must be supported suitably to avoid injuring the rather frail double-walled vacuum cylinders used to hold the liquid air.

Direct immersion is employed only where no alternate method is available. Such is the case with the bronze sleeve used in the M-4 gun mount, as assembled by the Ford Motor Co., Dearborn, Mich. (which has been shrink fitting valve seats in cylinder blocks as a standard operation for 10 years).

This bronze sleeve is 10 in. long, has an O.D. of 6.880-0.002 in., wall thickness of 0.205 in., weight of 13¼ lbs. It is fitted into a tube whose I.D. is 6.875 + 0.002 in. The press averages 0.003 in. A 15-min. immersion of the sleeve in liquid air produces a shrinkage of 0.002 in., which is necessary for satisfactory assembly since the sleeve not only warms up and expands rapidly during the interval of assembly but the tube contracts as it is cooled by contact with the sleeve. A volume of 100 cu. in. of liquid air is used in cooling one sleeve. This in addition to 10 cu. in. of air evaporated by heat leaking into the vacuum container from the outside. The above data are furnished by R. H. McCarroll of the chemical and metallurgical department of Ford.

## Some General Rules

Mr. McCarroll lays down the general proposition that shrink fitting requires the use of inserts with outside diameters 0.001 to 0.003 in. larger than inside diameter of the hole. For satisfactory insertion the shrinkage necessary may have to be much greater than the difference in diameters. The theoretical shrinkage may be adequate for very short inserts such as valve seat inserts. Very long bushings may require a shrinkage 5 to 10 times the actual difference in dimensions to permit satisfactory assembly.

In the present production of war equipment by the Ford Motor Co., the shrink fit assembly method has many applications, with the following five prominent: Assembly of small aluminum bushings in aluminum castings, steel sleeves in aluminum cylinder blocks, iron sleeves in iron cylinder blocks, bronze bushings in steel castings and steel inserts in aluminum forgings.

## Experience of Chrysler, Dodge Division

The Dodge division, Chrysler Corp., Detroit, first tried out shrink fits in 1932, using dry ice, but since "Deepfreeze" has developed a cabinet and machinery with rating of —120 deg. F. and actual accomplishment of —150 deg. F., this is used quite extensively.

In some cases the dry ice and mechanical refrigeration are used simultaneously. Thus valve inserts and drive shaft bearing cups are shrunk at the same time. The valve insert, which has a very small cross section, is chilled with dry ice which does not go below —109 deg. F. while the bearing cups, with larger cross section and different metal composition, is chilled in a Deepfreeze unit, down to —120 deg. F., both soaking 15 min. and shrinking 0.002 in.

*Two piston parts that are to be mated with shrink fit technique.*

The valve inserts are made of a wear- and heat-resistant alloy, containing more carbon, molybdenum and chromium than the cup. These inserts are round collars made of close-grained alloy casting M.S.926 and have the same coefficient of expansion as cast iron and composition as follows: C 1.80 to 2.20, Mo 4.7 to 5.2, Cr 2.7 to 3.2, Si 1.0 to 1.5, Mn 0.40 to 0.60 per cent. They are ground to an O.D. of 1.515 to 1.5145 in. and an I.D. of 1.276 to 1.286 in., thickness of 0.250 in. and check to Rockwell C 50 to 60.

The bearing cups have the following composition: C, 0.17 to 0.22; Mn, 0.45 to 0.65; P, max. 0.40; S, max. 0.40; Si, 0.20 to 0.35; Ni, 1.65 to 2.00; Mo, 0.20 to 0.30, made from M.S. 419. The dimensions of the bearing cups are: Thickness, 1.375 in.; O.D. 8.1250 to 0.55; largest I.D. 7.6402 in tapering to a smaller I.D. on a 34 deg. angle.

Among other components treated by Dodge in its Deepfreeze units are: Seals, gear hubs, drive shafts, spring lever pins and shock spring pins.

States E. J. Poag of the Dodge division: "Since 1932 Deepfreeze units have been developed to where they can bring the temperature down to —150 deg. F. at a reduced ratio of cost of about 1 to 17 as against dry ice. In other words, $175 spent for electric current will do as much as $3000 spent for dry ice in the same period of time." [We wonder, though, if the higher original cost of the mechanical refrigeration has been included.—Editor]

## Fitting Bronze Bushings Into Pistons

According to Don P. Shaw, manager, Ohio Piston Co., Cleveland, his company's problem involved fitting bronze bushings into pistons. The normal procedure at the time they took this job was to expand the piston by heat and drop the bushing in

place. This was quite slow and expensive. Therefore, a method of using liquid air with dry ice as a pre-cooler was developed. This eliminated the delay in production which more than offset the increased cost — a total cost of $1 per unit.

This company expects to produce at the rate of 17,000 units per month and is now using two Deepfreeze machines, which handle the problem much more efficiently than was possible with liquid air or with dry ice, Mr. Shaw reports. Aside from this, he stresses the tremendous difference in the cost of operation.

The experiences of an Ohio machine tool builder were, briefly, as follows: The company has four subzero units operating at about —50 deg. F., used to shrink bearing cups into assemblies. They find this method to be three times as fast as press or driving into position. Improved quality of the finished product results as the bearing faces are free from the burrs which sometimes accompany a drive fit.

The cup shrinkage is approximately 0.001 in. per in. of diam. The cooling medium in the cold units is a solution of kerosene and alcohol, which also serves to reduce corrosion and condensation and which facilitates safer handling.

## A Bearing Race Into a Malleable Housing

In another instance, service reports have shown no loosening after one year's high production, according to R. W. Roush, chief metallurgist, Timken-Detroit Axle Co., Detroit, in a case where the job is shrinking a tapered roller bearing race into a malleable iron housing.

Specifications for the job are: Shrink fit is 0.0015 in.; I.D. of housing about 4⅜ in.; wall thickness, ½ in.; bearing race (Timken No. 3920) is 4⅜ in. O.D. and a tapered tubular member 1 in. long; wall thickness of bearing race at one end, 13/32 in. — at the other end, 5/32 in.

The bearing race is SAE 4620 steel, carburized all over, quenched in oil, reheated and quenched in oil and tempered at 350 deg. F. The case structure is fine martensite; and the hardness is Rockwell C 60-63: The surface has a high polish.

The bearing is placed in a Deepfreeze unit at —40 deg. F. and held 1 hr. It is removed and placed in the housing with a very light press. When warmed to room temperature, it is naturally secured firmly to the housing.

Another manufacturer shrinks a bronze wrist pin bushing into a piston for a diesel engine. Previously he used liquid oxygen but has more recently used mechanical refrigeration, securing a shrinkage of 0.005 in. in an outside diameter of 3.3190 in. and saving $3000 to $4000 per month over the use of liquid oxygen. Liquid air was too costly, too difficult to obtain and required the services of two men. Dry ice also proved impractical and costly.

## Assembling Airplane Landing Struts

Another problem involved the assembling of airplane landing struts. The process finally developed consisted of shrinking the male part in a —120 deg. F. chilling unit and expanding the female part in a 450 deg. F. oil bath. Both parts were of steel. The amount of shrink in one part was 0.003 in. and the amount of expansion in the mated part was 0.005 in., the diameter of each part being 4.843 in. and each treatment taking 5 min. By the former method of heating the female part only, the total time was 20 min.

The financial saving over dry ice, used prior to mechanical refrigeration, was $30 per day. When heating the female part only there were several unsatisfactory features. Operators could not hold to an even temperature and there were many rejects, requiring pulling apart or disassembling. Dry ice took too much time to crack and prepare.

Liquid nitrogen, cold to the extent of —410 deg. F., is used by General Electric Co. at Schenectady to shrink steel parts used in making electrical apparatus. It allows a diameter clearance of slightly less than 0.002 in. between the steel part and the hollow tungsten carbide cylinder which is later fitted over it to form a complete punch.

...

# Improved 12 Per Cent Chromium Steel

## —Containing Molybdenum

**A progress report released by the Allegheny Ludlum Steel Corp., Brackenridge, Pa., and the Babcock & Wilcox Tube Co., Beaver Falls, Pa., who have been jointly conducting research on certain alloy steels.**

*High-temperature behavior, room-temperature properties, corrosion resistance and costs must all be considered in the selection of steels for service in oil refineries, steam power systems, etc. Any improvement in existing materials in one direction must be accomplished without serious harm in others. The data reported in this "preliminary" note show that the 12 per cent Cr steels have generally better properties in several important respects if 1 per cent Mo is included in the composition.*

*—The Editors*

CHROMIUM STEELS OF ALL GRADATIONS of chromium content find application in high-temperature, corrosion-resistant uses, of which that as oil refinery tubing is particularly important. Economics plays a major part in the selection of steel for such use, that is, at each level of increasing severity in service, life must be extended in correspondence with the increment of cost.

The utility of a steel in actual service requires freedom from many undesirable attributes as well as possession of a sufficient degree of several desirable ones. These attributes may be controlled to a considerable degree, by relatively small additions of other alloying elements. Hence it becomes necessary to evaluate the effect of such additions, alone, and in combination. The problem arises afresh at each chromium level of the chromium steels.

In a complete study of the augmenting of the desirable properties of 12 per cent Cr steel the effects of the additions upon properties after various heat treatments, upon oxidation resistance, upon load-carrying ability, upon stability against embrittlement, etc., etc., will have to be evaluated. This evaluation is not yet complete; the present discussion is offered as a progress, rather than a final report.

Outstanding among the properties it is desired to improve, is that of load-carrying ability, primarily evaluated on the basis of long-time creep resistance. Because of the known favorable influence of molybdenum upon creep resistance, it was taken for granted that a molybdenum addition would be required. However, since creep tests are so time-consuming, the study was planned first to evaluate the effect of the additions on the basis of other tests, and finally to make creep tests upon a few of the more promising variations. Creep tests on some tentatively selected compositions are in progress and those on other compositions planned. That chapter of the work must be completed before final conclusions may be drawn, but an approximate appraisal may be made on the basis of the other information available, without delaying the report for inclusion of creep data.

The effect of molybdenum was studied by means of 60 lb., 4 in. by 4 in. by 13 in. (after cropping the hot top) ingots from basic high frequency induction furnace melts, forged at 2100 to 2150 deg. F. to 1-1/16-in. rounds. The steels were annealed 1 hr. at 1675 deg. F. cooled at 40 deg. per hr. to 1100 deg., then air-cooled. The compositions were:

| *Heat No.* | *C* | *Mn* | *Si* | *Cr* | *Mo* |
|---|---|---|---|---|---|
| 950 | 0.106 | 0.33 | 0.30 | 12.02 | None |
| 951 | 0.106 | 0.33 | 0.33 | 12.02 | 0.53 |
| 952 | 0.108 | 0.30 | 0.35 | 12.10 | 1.00 |
| 953 | 0.11 | 0.30 | 0.33 | 12.05 | 1.46 |
| 954 | 0.10 | 0.25 | 0.31 | 11.97 | 2.00 |

### Room Temperature Properties

The room temperature properties of the annealed steels are given in Table I. The short-time high temperature properties determined over the range 800 to 1300 deg. F. are given in Table II. The increase in strength due to molybdenum is evident. Charpy key-hole notch impact results in ft. lbs. follow for annealed materials:

| *Heat No.* | *Mo per cent* | *Room Temp.* | *25 deg. F.* | *—25 deg. F.* |
|---|---|---|---|---|
| 950 | None | 30 - 30 | 28 - 29 | 20 - 23 |
| 951 | 0.53 | 30 - 33 | 28 - 32 | 18 - 22 |
| 952 | 1.00 | 27 - 30 | 26 - 28 | 25 - 27 |
| 953 | 1.46 | 22 - 33 | 26 - 31 | 3 - 11 |
| 954 | 2.00 | 10 - 25 | 8 - 15 | 2 - 4 |

*Table I. Room Temperature Properties of the Annealed Steels*

| Heat No. | Mo Per Cent | Tensile, Lbs. per sq. in. | Yield, Lbs. per sq. in.[1] | Prop. Lim., Lbs. per sq. in.[2] | Elong., Per Cent | R.A., Per Cent | Brinell |
|---|---|---|---|---|---|---|---|
| 950 | None | 72,500 | 38,700 | 19,500 | 37 | 69 | 143 |
| 951 | 0.53 | 72,500 | 39,400 | 21,000 | 36 | 68 | 143 |
| 952 | 1.00 | 77,200 | 43,000 | 22,500 | 37 | 67 | 156 |
| 953 | 1.46 | 75,500 | 45,200 | 25,000 | 35 | 65.5 | 156 |
| 954 | 2.00 | 72,200 | 45,200 | 26,500 | 35 | 63.5 | 150 |

[1] Offset = 0.2 per cent of gage length.
[2] Offset = determined with extensometer sensitive to 0.000066 in. specimens loaded by increments of 200 lbs.

*Table II. Physical Properties at Elevated Temperatures*

| Heat No. | Molybdenum per cent | Temp., deg. F. | Ultimate, Lbs. per sq. in. | Yield* Lbs. per sq. in. | Elong. per cent in 2 in. | *Area, per cent* Red. in |
|---|---|---|---|---|---|---|
| 950 | — | 800 | 55,500 | 33,500 | 31 | 68.2 |
| | | 900 | 45,200 | 27,000 | 33 | 69.2 |
| | | 1000 | 38,750 | 25,700 | 41 | 74.1 |
| | | 1100 | 27,200 | 23,000 | 49 | 85.8 |
| | | 1200 | 19,300 | 13,850 | 62 | 91.0 |
| | | 1300 | 11,250 | 10,000 | 66 | 95.5 |
| 951 | 0.53 | 800 | 56,750 | 35,000 | 29 | 67.0 |
| | | 900 | 48,200 | 31,600 | 33 | 69.2 |
| | | 1000 | 40,500 | 25,500 | 35 | 73.5 |
| | | 1100 | 30,050 | 25,000 | 48 | 82.7 |
| | | 1200 | 20,000 | 15,250 | 63 | 89.7 |
| | | 1300 | 17,150 | 10,700 | 68 | 97.0 |
| 952 | 1.00 | 800 | 58,000 | 40,000 | 28 | 63.5 |
| | | 900 | 52,500 | 31,000 | 34 | 69.2 |
| | | 1000 | 44,300 | 30,200 | 36 | 73.0 |
| | | 1100 | 33,500 | 26,400 | 47 | 79.5 |
| | | 1200 | 22,750 | 17,500 | 64 | 89.5 |
| | | 1300 | 15,100 | 11,800 | 72 | 95.0 |
| 953 | 1.46 | 800 | 58,500 | 41,000 | 29 | 64.6 |
| | | 900 | 51,500 | 32,300 | 34 | 68.1 |
| | | 1000 | 46,200 | 35,000 | 35 | 73.5 |
| | | 1100 | 35,600 | 27,300 | 50 | 83.0 |
| | | 1200 | 26,600 | 20,600 | 58 | 87.3 |
| | | 1300 | 15,800 | 12,300 | 71 | 96.8 |
| 954 | 2.00 | 800 | 57,000 | 42,700 | 30 | 65.8 |
| | | 900 | 52,500 | 33,200 | 30 | 65.9 |
| | | 1000 | 46,200 | 34,000 | 35 | 69.7 |
| | | 1100 | 34,800 | 24,800 | 39 | 77.7 |
| | | 1200 | 25,750 | 19,500 | 53 | 86.0 |
| | | 1300 | 17,750 | 14,000 | 61 | 93.7 |

* Yield from Amsler stress-strain diagram.

*Table III. Results of Charpy Impact Tests*

| Heat No. | Molybdenum Per Cent | Room Temp. | | 25 deg. F. | | —25 deg. F. | |
|---|---|---|---|---|---|---|---|
| | | Rapid cool | Slow cool | Rapid cool | Slow cool | Rapid cool | Slow cool |
| 950 | None | 40 - 43 | 40 - 46 | 35 - 38 | 40 - 44 | 27 - 33 | 34 - 37 |
| 951 | 0.53 | 35 - 42 | 41 - 41 | 31 - 35 | 35 - 37 | 25 - 27 | 27 - 33 |
| 952 | 1.00 | 28 - 30 | 30 - 34 | 25 - 26 | 30 - 34 | 22 - 25 | 28 - 32 |
| 953 | 1.46 | 28 - 30 | 30 - 33 | 22 - 26 | 28 - 31 | 8 - 22 | 10 - 25 |
| 954 | 2.00 | 27 - 30 | 12 - 26 | 8 - 20 | 8 - 17 | 4 - 7 | 6 - 10 |

Charpy impact tests were also made on quenched and tempered materials, rapidly and slowly cooled after tempering, to evaluate any tendency toward temper brittleness. The treatment was 1675 deg. F.—1 hr., oil; draw 1200 deg. F., 4 hrs. One set, water quench, the other set slow cool at 10 deg. F. per hr. down to 650 deg. F. The results are given in Table III. No temper brittleness is indicated. The same low temperature effect is apparent as was observed for the annealed specimens.

The effect of the higher molybdenum contents is obviously due to depression of the alpha to gamma transformation. With 2 per cent Mo the steel has been brought so near the tip of the gamma loop that too little of it undergoes the gamma-alpha transformation; it is too near to a completely non-transformable alpha-delta steel to be satisfactorily refinable by heat treatment. Hence it is coarse-grained and relatively brittle.

This is also brought out by the microstructures, Figs. 1 to 10. It is also reflected in the hardenability on air cooling or water quenching specimens 1-1/16 in. diam. by ½ in. long, as shown in Figs. 11 and 12. Weld hardening data, obtained by laying down a single bead of soft steel welding rod on annealed specimens, showed, for the heat-affected zone:

| *Heat No.* | *Mo per cent* | *Rockwell C* | *Brinell* |
|---|---|---|---|
| 950 | None | 40 | 370 |
| 951 | 0.53 | 41 | 381 |
| 952 | 1.00 | 41 | 381 |
| 953 | 1.46 | 36 | 331 |
| 954 | 2.00 | 26 | 252 |

Welding without subsequent tempering or annealing would make any of these steels relatively brittle; preheating for welding would of course be required.

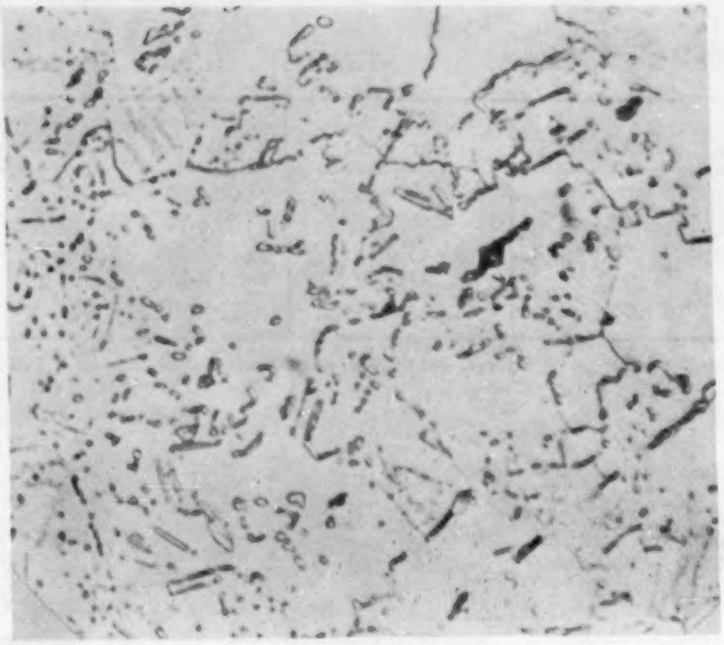


*Fig. 2. Heat 950. Etch: Aqua regia. 1,000X.*

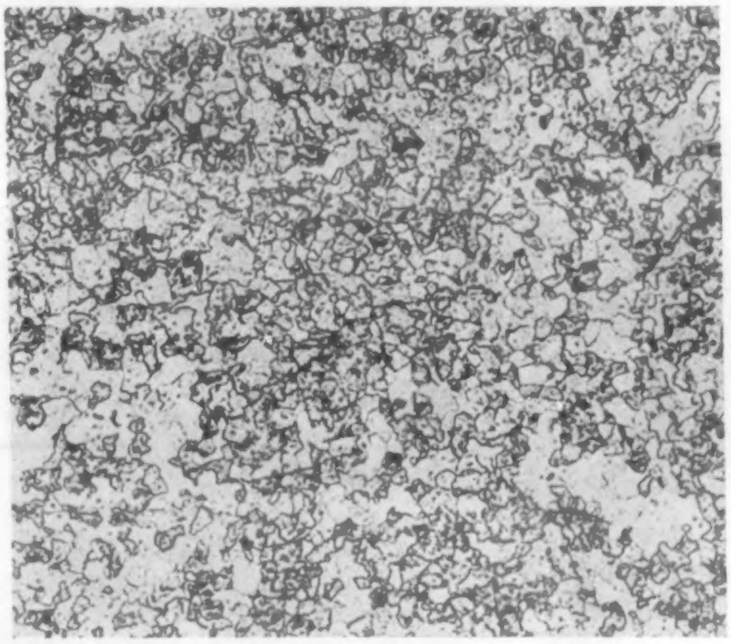


*Fig. 3. Heat 951. Etch: Aqua regia. 100 X.*

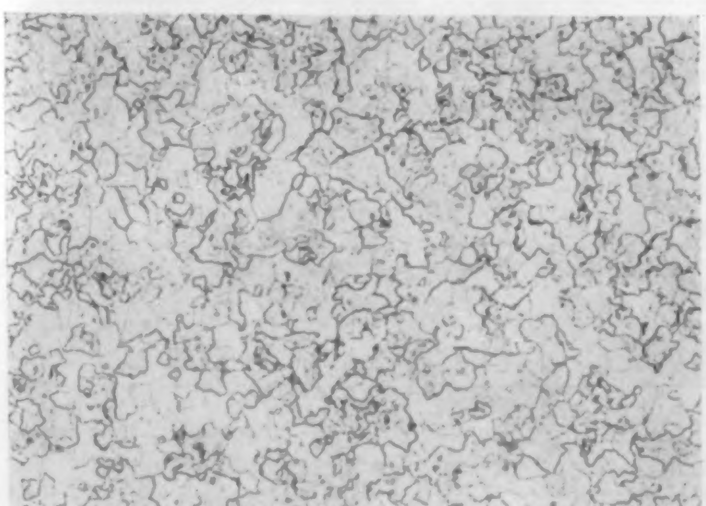


*Fig. 1. Heat 950. Etch: Aqua regia. 100X.*

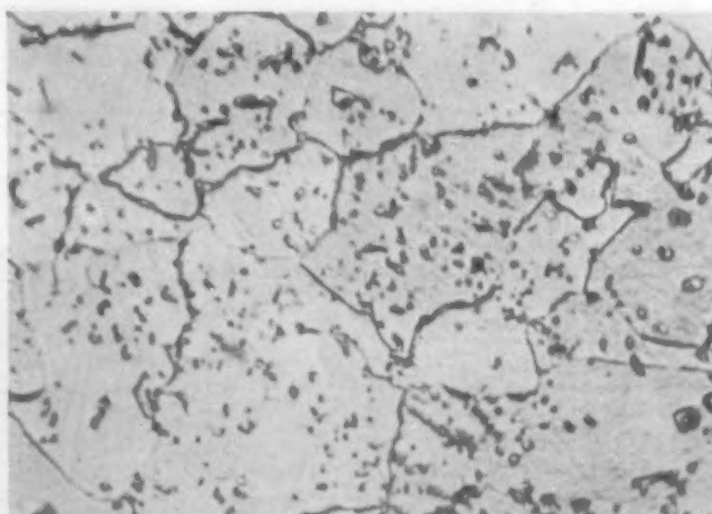


*Fig. 4. Heat 951. Etch: Aqua regia. 1,000X.*

*Table IV. Room Temperature Properties After Aging*

| Heat No. | Molybdenum, Per Cent | Tensile, Lbs. per sq. in. | Yield, Lbs. per sq. in. | Elong., Per Cent | Red. of Area, Per Cent |
|---|---|---|---|---|---|
| 950 | None | 68,000 - 73,000 | 28,500 - 37,500 | 33 - 39 | 68 - 72 |
| 951 | 0.53 | 69,000 - 73,000 | 32,000 - 36,000 | 33 - 38 | 67.5 - 71.5 |
| 952 | 1.00 | 74,000 - 77,500 | 36,000 - 38,500 | 33 - 37 | 63 - 68 |
| 953 | 1.46 | 71,500 - 75,500 | 34,500 - 39,500 | 31 - 36 | 58.5 - 69 |
| 954 | 2.00 | 72,000[1] - 78,000 | 36,000 - 44,000 | 26 - 35 | 54.5 - 64.5 |

[1] Except one value 64,400 after 500 hrs. at 1,200 deg. F.

*Table V. Tests of Charpy Impact Bars After Aging*

| Heat No. | Mo Per Cent | Annealed, Unaged Aver. | Aged at 900 deg. F. | | | Aged at 1,000 deg. F | | |
|---|---|---|---|---|---|---|---|---|
| | | | 500 hrs. | 1,000 hrs. | 1,500 hrs. | 500 hrs. | 1,000 hrs. | 1,500 hrs. |
| 950 | None | 30 | 42 - 52 | 54 - 60 | 49 - 53 | 52 - 54 | 51 - 57 | 56 - 57 |
| 951 | 0.53 | 31 | 30 - 44 | 27 - 30 | 28 - 30 | 31 - 36 | 31 - 33 | 34 - 36 |
| 952 | 1.00 | 28 | 35 - 38 | 34 - 36 | 39 - 40 | 32 - 35 | 32 - 37 | 29 - 30 |
| 953 | 1.46 | 27 | 38 - 44 | 25 - 33 | 35 - 38 | 26 - 32 | 33 - 40 | 32 - 40 |
| 954 | 2.00 | 17 | 25 - 28 | 17 - 20 | 10 - 28 | 26 - 36 | 10 - 25 | 8 - 28 |

| Aged at 1,100 deg. F. | | | Aged at 1,200 deg. F. | | |
|---|---|---|---|---|---|
| 500 hrs. | 1,000 hrs. | 1,500 hrs. | 500 hrs. | 1,000 hrs. | 1,500 hrs. |
| 53 - 58 | 59 - 65 | 50 - 56 | 34 - 37 | 33 - 39 | 51 - 53 |
| 34 - 40 | 34 - 35 | 30 - 37 | 39 - 40 | 39 - 42 | 39 - 42 |
| 32 - 39 | 30 - 31 | 30 - 34 | 32 - 34 | 34 - 40 | 38 - 47 |
| 27 - 28 | 22 - 25 | 22 - 26 | 22 - 25 | 24 - 27 | 21 - 22 |
| 10 - 17 | 5 - 14 | 10 - 20 | 22 - 25 | 24 - 27 | 21 - 22 |

*Table VI. Room Temperature Properties*

| | Tensile Lbs. per sq. in. | Elong., Per Cent | R. A., Per Cent | Brinell | Izod |
|---|---|---|---|---|---|
| Annealed at 1675 deg., 1 hr. cooled 40 deg. F./hr. to 1100 deg., then air cooled | | | | | |
| 32634 0.34% Si | 67,000 | 38.0 | 71.5 | 152 | 5.0 |
| 32633 1.10% Si | 72,000 | 37.0 | 73.5 | 162 | 3.0 |
| Normalized from 1675 deg. F., drawn 700 deg. F. | | | | | |
| 32634 0.34% Si | 161,000 | 20.0 | 67.5 | 323 | 79.0 |
| 32633 1.10% Si | 141,000 | 20.0 | 58.5 | 283 | 7.0 |
| Drawn 900 deg. F. | | | | | |
| 32634 0.34% Si | 166,500 | 22.0 | 62.5 | 337 | 10.5 |
| 32633 1.10% Si | 145,000 | 21.0 | 55.5 | 277 | 4.0 |
| Drawn 1,100 deg. F. | | | | | |
| 32634 0.34% Si | 119,000 | 24.0 | 71.0 | 255 | 107.0 |
| 32633 1.10% Si | 108,000 | 26.0 | 69.5 | 229 | 33.0 |
| Drawn 1,300 deg. F. | | | | | |
| 32634 0.34% Si | 97,000 | 28.0 | 73.5 | 209 | 108.0 |
| 32633 1.10% Si | 93,000 | 29.5 | 69.0 | 195 | 49.0 |

Aging tests were run on annealed material at 900, 1000, 1100 and 1200 deg. F. for 500, 1000 and 1500 hrs. Room temperature tensile properties after these aging treatments were not affected by time or temperature of heating, that is, they were within the limits expected for duplicate specimens except in the case of Heat 954, with 2 per cent Mo. The extremes of properties in the 12 per cent Cr aged specimens are given in Table IV.

Charpy impact bars were similarly aged, and then broken at room temperature. The ranges in ft.-lbs. on these bars are found in Table V. The values after aging are closer to those obtained on quenched and 1200 deg. tempered specimens than to those on unaged annealed specimens. The low and erratic impact values of the 2 per cent Mo steel are improved by the 1200 deg. aging treatments. On the whole the properties after aging are not only the best but most uniform for the 1 per cent Mo steel.

The effect of increasing the silicon was studied in the selected analysis containing 1 per cent Mo. Electric furnace heats (basic) of 500 lb. each were rolled to 1 in. diam., using commercial practice and annealed at 1675 deg. F., 1 hr., cooled 40 deg. F. per hr. to 1100 deg., then air cooled. Their compositions were:

| *Heat* | *C* | *Cr* | *Mo* | *Si* | *Mn* | *Ni* | *S* | *P* |
|---|---|---|---|---|---|---|---|---|
| 32533 | 0.069 | 11.57 | 1.02 | 1.10 | 0.24 | 0.17 | 0.023 | 0.017 |
| 32633 | 0.063 | 12.02 | 1.16 | 0.34 | 0.28 | 0.12 | 0.025 | 0.017 |

The room temperature properties are given in Table VI. The 1.10 per cent Si steel either air hardens less or is more readily tempered, and has surprisingly low impact for its other properties at the low draw temperatures. In the annealed condition there is little difference between the two steels.

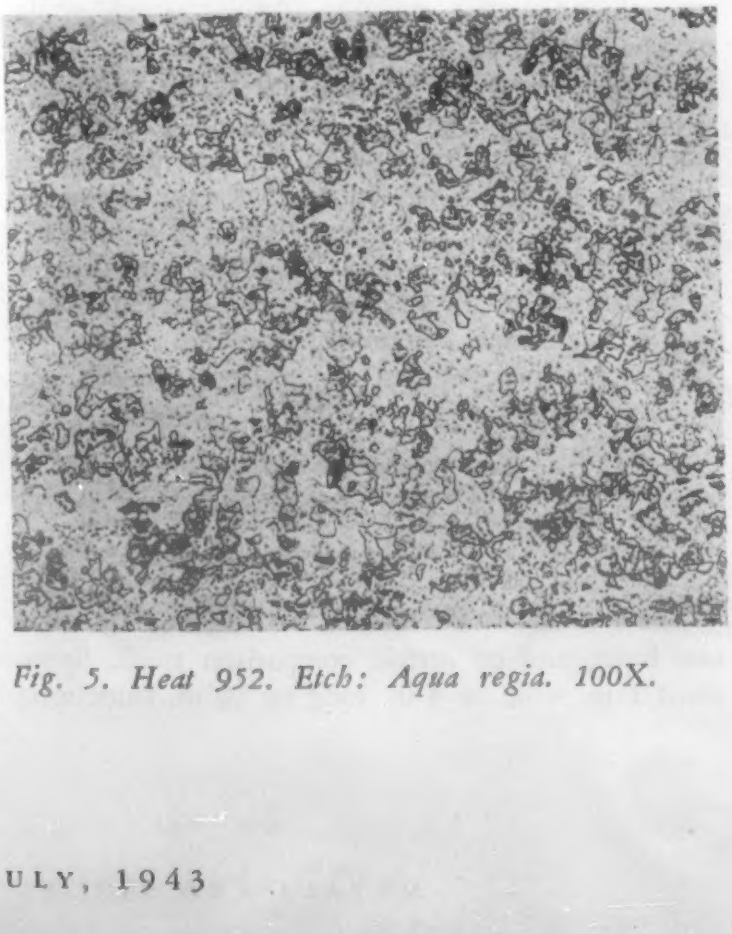


*Fig. 5. Heat 952. Etch: Aqua regia. 100X.*

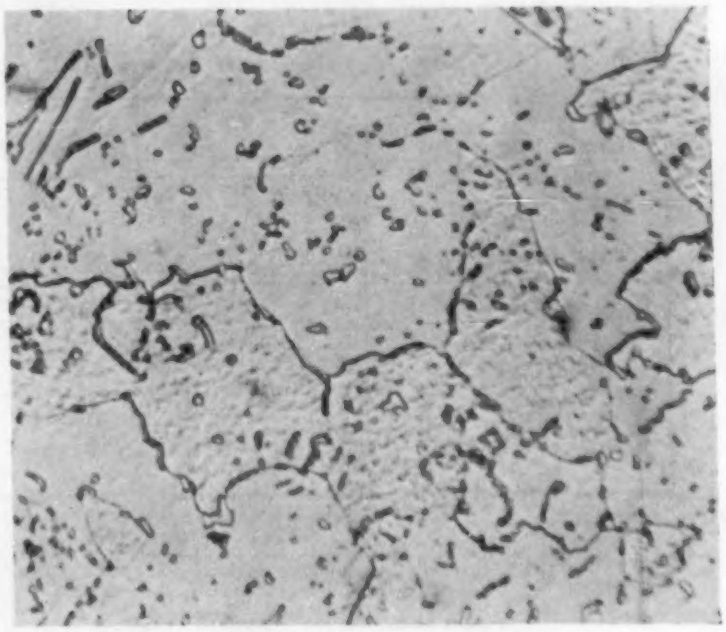


*Fig. 6. Heat 952. Etch: Aqua regia. 1,000X.*

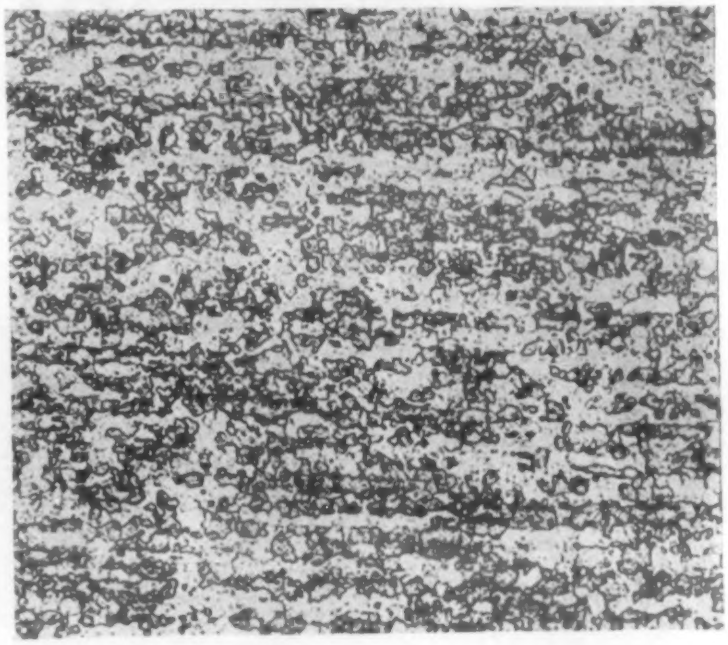


*Fig. 7. Heat 953. Etch: Aqua regia. 100X.*

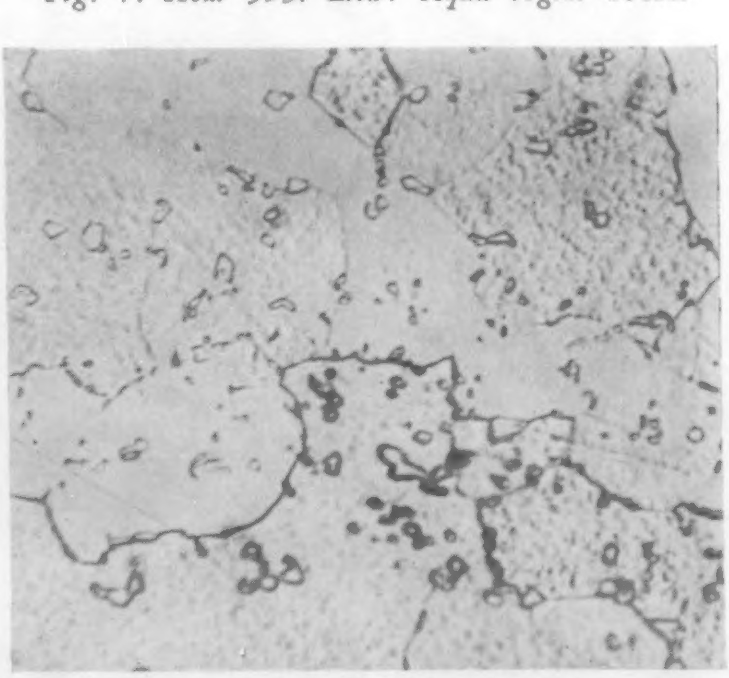


*Fig. 8. Heat 953. Etch: Aqua regia. 1,000X.*

*Table VII. Short-time High Temperature Properties of the Annealed Steels*

| Test Temperature → | 1000 deg. F. | 1100 deg. F. | 1200 deg. F. | 1300 deg. F. | |
|---|---|---|---|---|---|
| 0.34% Si | 39,000 | 28,000 | 15,500 | 10,600 | Tensile, lbs. per sq. in. |
| 1.10% Si | 39,500 | 28,000 | 17,800 | 10,300 | |
| 0.34% Si | 41.5 | 52.5 | 74 | 85.0 | Elong., Per Cent |
| 1.10% Si | 47.0 | 63.0 | 74 | 94.0 | |
| 0.34% Si | 77.5 | 86.5 | 93 | 97.5 | Red. of Area, Per Cent |
| 1.10% Si | 92.5 | 88.5 | 94 | 97.0 | |

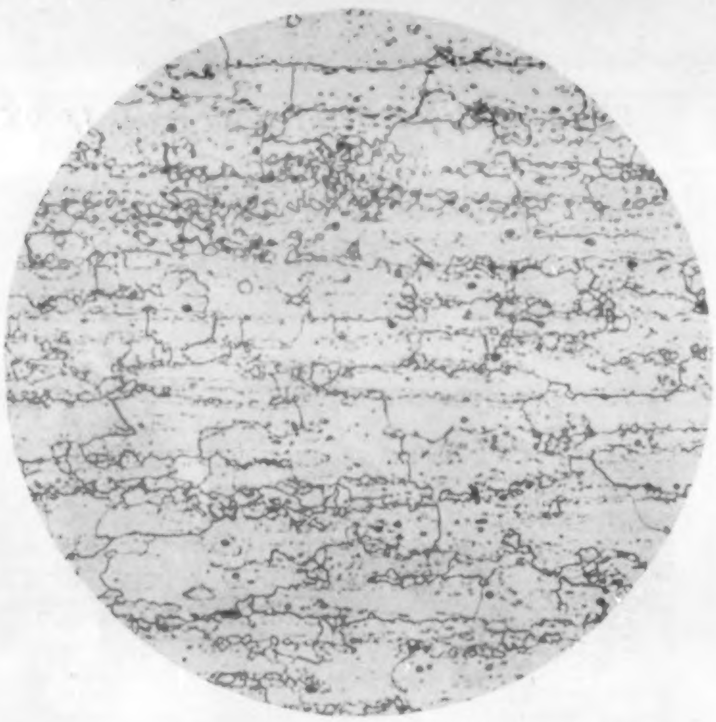


*Fig. 9. Heat 954. Etch: Aqua regia. 100X.*

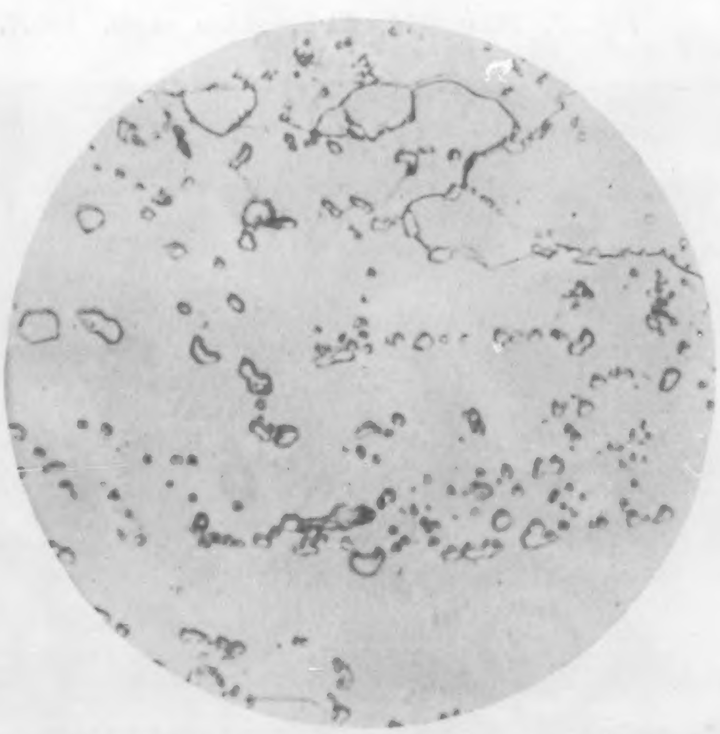


*Fig. 10. Heat 954. Etch: Aqua regia. 1,000X.*

## High-Temperature Properties

Short-time high temperature tests for the annealed steels are found in Table VII. The short-time high temperature properties at 1000 to 1300 deg. F. are not injured by raising the silicon.

These two heats were subjected to "load to fracture" tests, at 1100 and 1200 deg. F. in the quenched and tempered, and annealed conditions by the research laboratories of the General Electric Co., by whose kind permission the results shown in Figs. 13 and 14 are made available. From these curves the loads to break in 1000 hrs. are shown as:

| *Si, per cent* | | *1100 deg. F.* | *1200 deg. F.* |
|---|---|---|---|
| 0.34 | Annealed | 11,000 | 5,800 |
| 1.10 | Annealed | 10,800 | 5,200 |
| 0.34 | Quenched & | 15,000 | 6,600 |
| 1.10 | Tempered | 11,800 | 6,000 |

Fractures at the overloads employed to cause rupture in these tests were all ductile and transcrystalline. The fractured test bars, subjected to the hammer-blow test, were still tough and ductile at room temperature. These results indicate that embrittlement in service at the temperatures at which the materials could be used is not to be expected, even under conditions of overload far above reasonable design values. Load to rupture tests are not considered to be of direct value to the designer, but are aimed to bring out tendencies that might show up under abuse or accident. Creep values, of more direct use in arriving at proper design loads, are planned.

The effect of silicon upon the coefficient of expansion has been determined for the alloys. In (inches per inch per deg. F.) x $10^{-6}$, the data are:

| Heat | Si. Per cent | 70-400 deg. F. | 70-600 deg. F. | 70-800 deg. F. | 70-900 deg. F. |
|---|---|---|---|---|---|
| 32634 | 0.34 | 6.07 | 6.33 | 6.48 | 6.64 |
| 32633 | 1.10 | 6.15 | 6.40 | 6.53 | 6.68 |

The resistance to oxidation was studied on these two heats, and on certain comparison steels. Specimens 1 in. wide by 4 in. long by 1/8 in. thick were

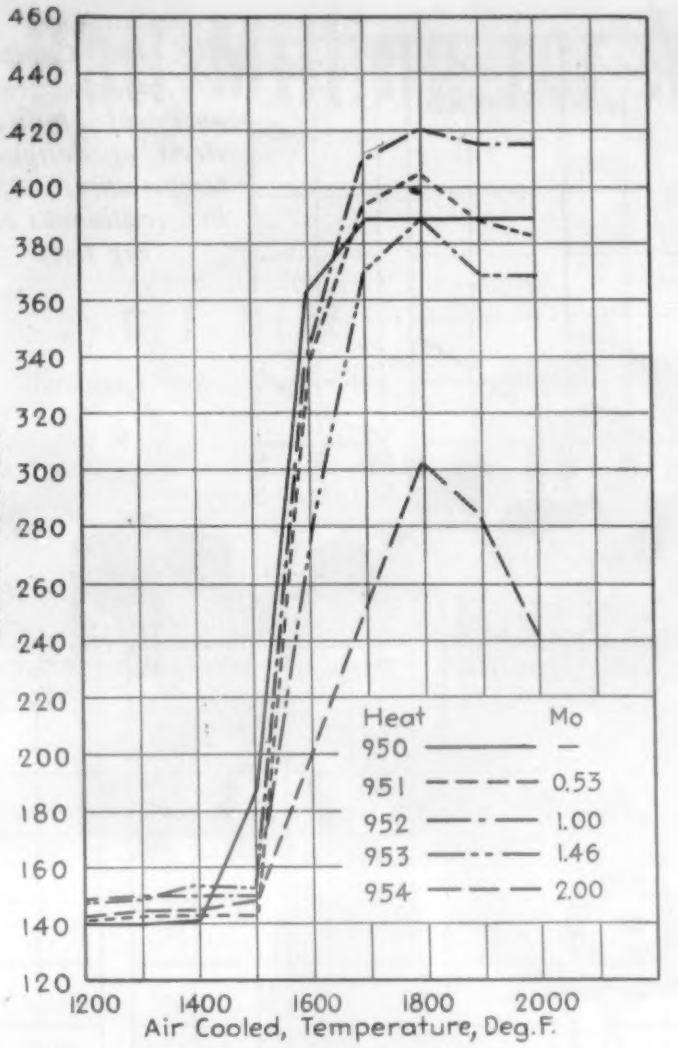



*Fig. 11. Heating cycle and hardening data.*

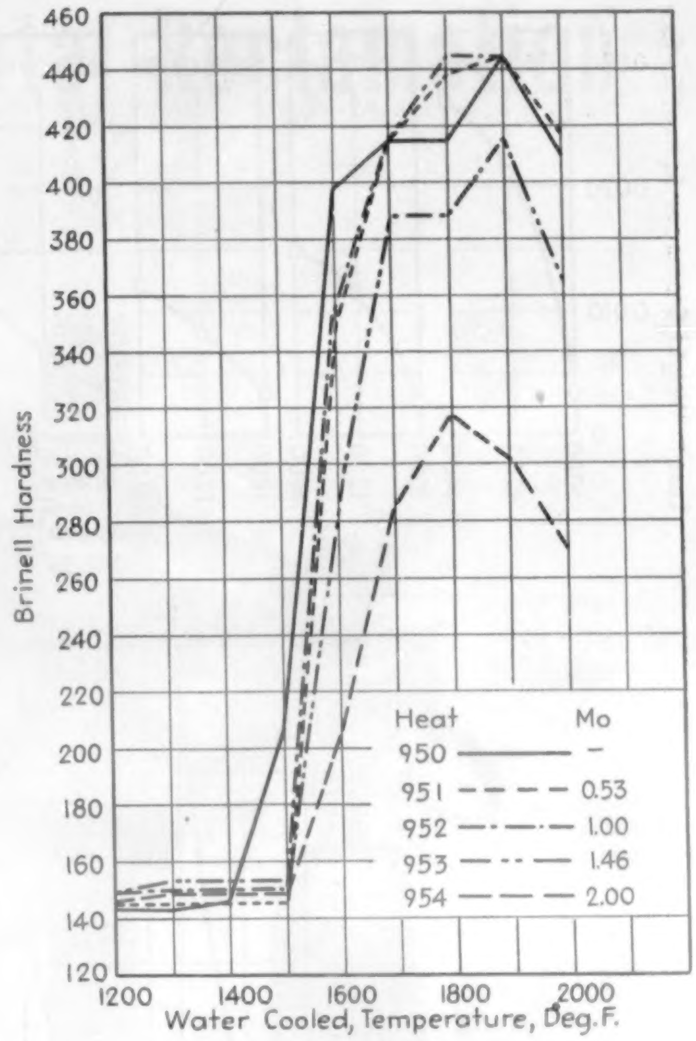



*Fig. 12. Heating cycle and hardening data.*

1.10Si

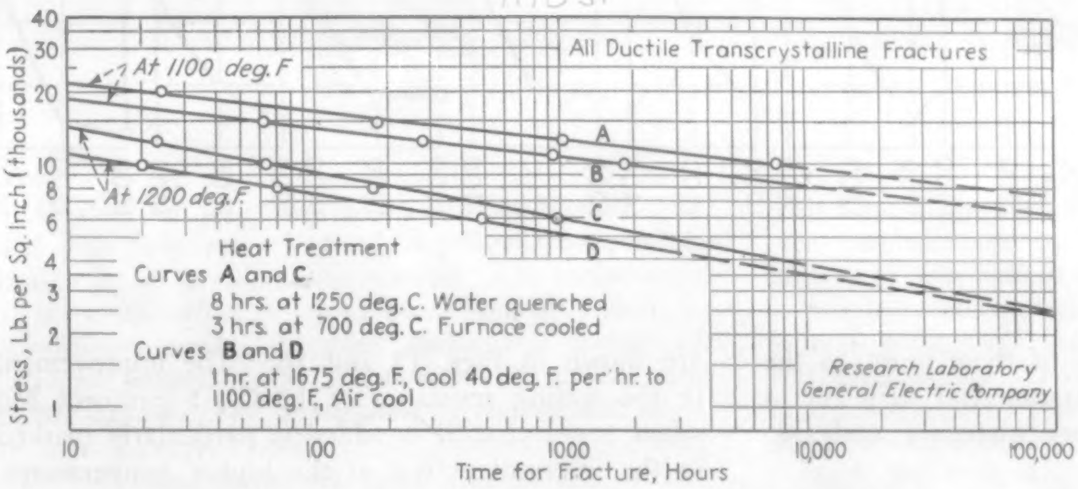



*Fig. 13.*
***Stress-rupture tests.***

0.34Si

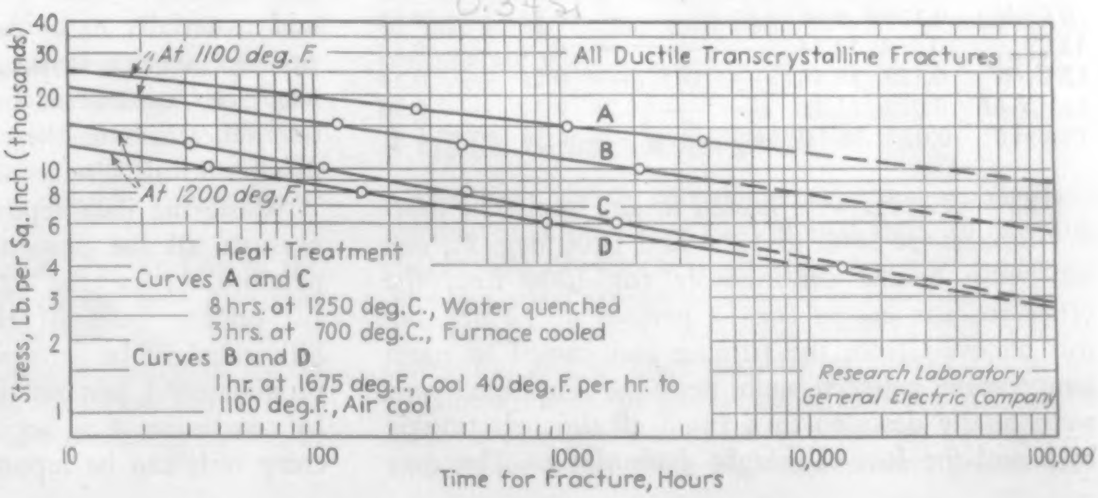



*Fig. 14.*
***Stress-rupture tests.***

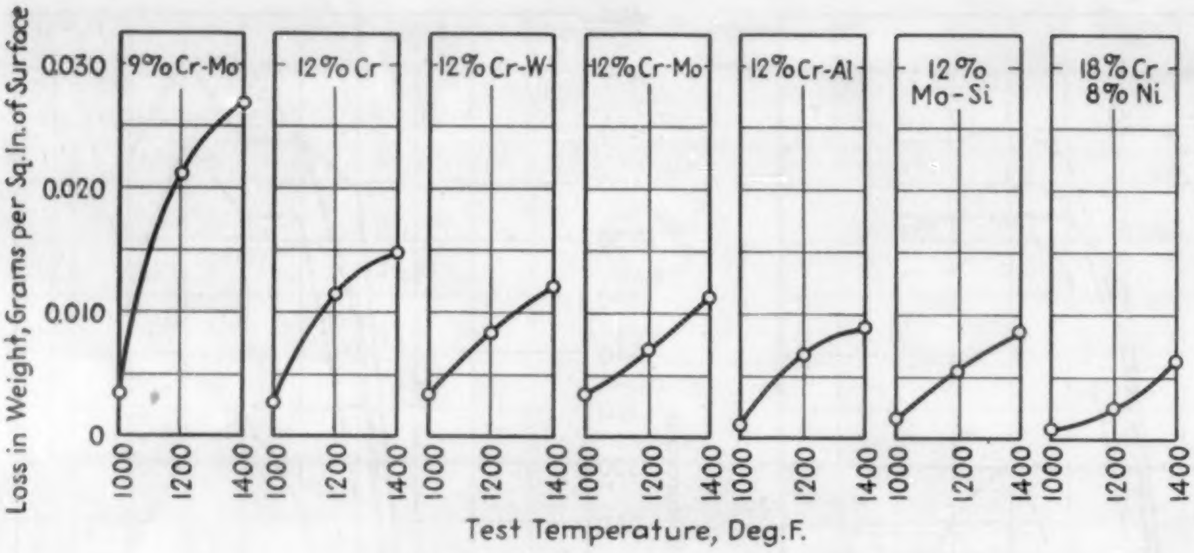



*Fig. 15. Comparative oxidation resistance of indicated steels at designated temperatures. 1,000 hrs. continuous heating tests.*

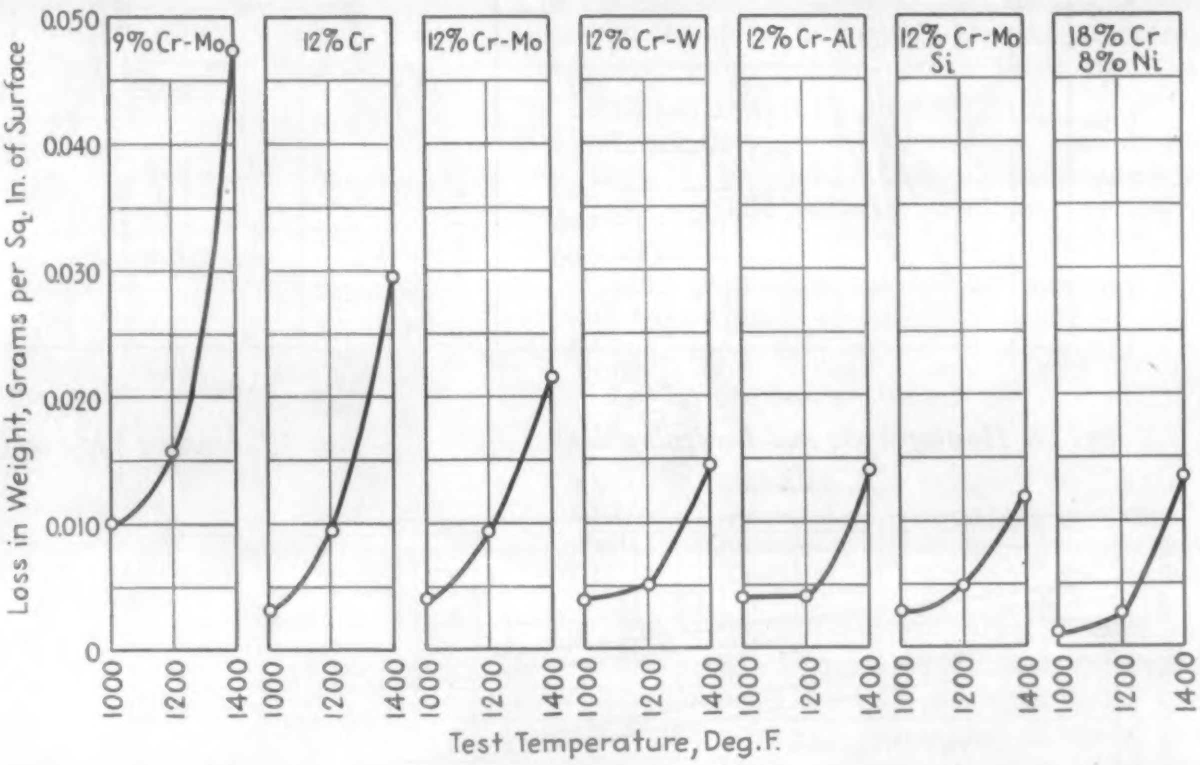



*Fig. 16. Comparative oxidation resistance of indicated steels at designated temperatures. Intermittent heating tests.*

machined from the bar stock of these heats, as the comparison specimens were commercial strip cut to those dimensions. The other materials analysed:

| | *C* | *Cr* | *Mo* | *W* | *Al* | *Si* | *Ni* | *Mn* |
|---|---|---|---|---|---|---|---|---|
| 9 Cr-Mo | 0.128 | 9.66 | 1.09 | — | — | 0.35 | — | 0.42 |
| 12 Cr | 0.088 | 12.74 | — | — | — | 0.21 | — | 0.32 |
| 12 Cr-W | 0.128 | 13.48 | — | 3.45 | — | 0.26 | — | 0.54 |
| 12 Cr-Al | 0.078 | 13.22 | — | — | 0.26 | 0.34 | — | 0.26 |
| 18 and 8 | 0.07 | 18.16 | — | — | — | 0.38 | 8.70 | 0.31 |

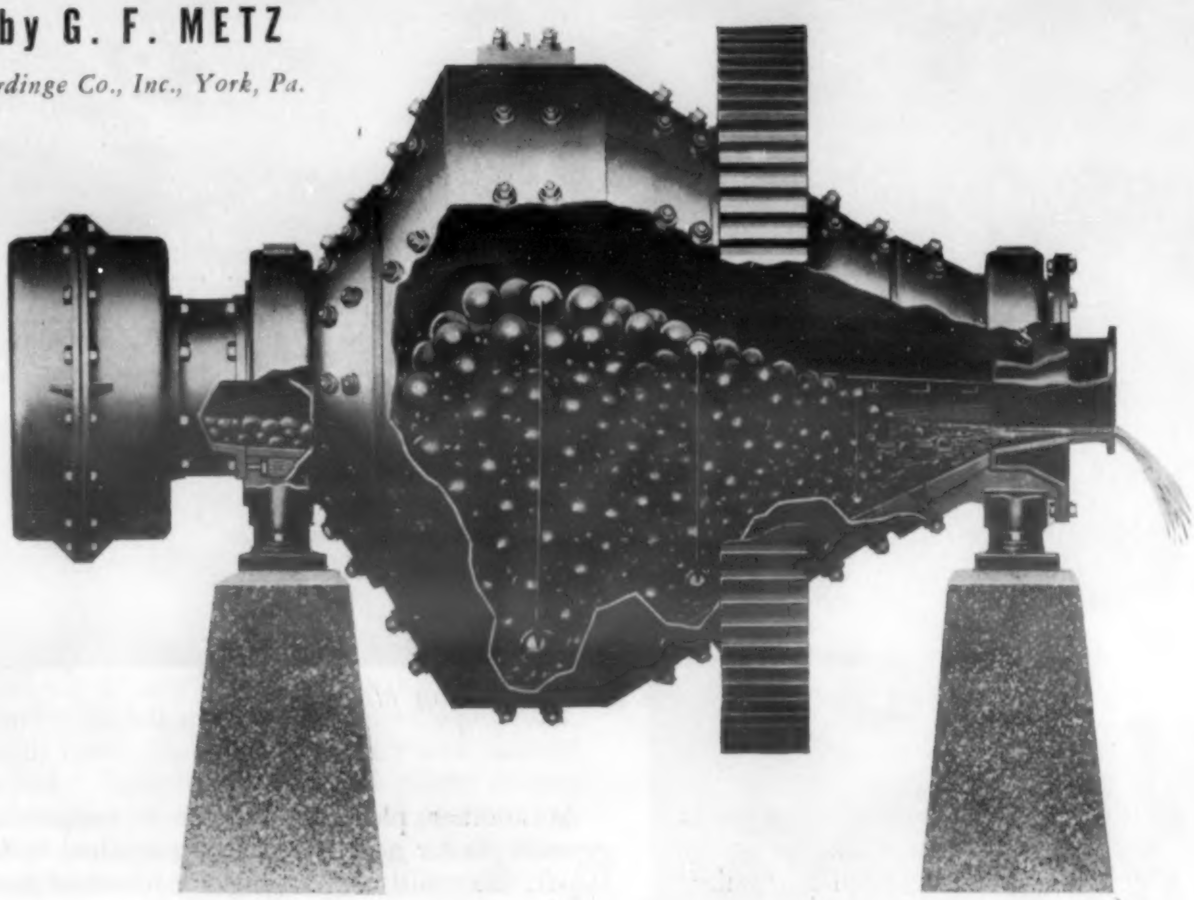
The specimens were heated in air, in electric muffle furnaces, at 1000 to 1200 and 1400 deg. F., one set being heated continuously for 1000 hrs., the other set was heated for 12 periods of 24 hrs. being removed from the furnace and cooled to room temperature between each period. The specimens were finally descaled in a fused alkaline electrolytic bath and the loss of weight determined. The data are shown in Figs. 15 and 16. The improvement in the scaling resistance of 12 Cr, 1 per cent Mo when 1 per cent Si is added is particularly marked in the intermittent test at the higher temperatures. Since there is some evidence that silicon does not add materially to oxidation resistance in high temperature service in the presence of certain combustion gases, or to resistance against oxidation by steam, the indications of these tests in air may not be applicable to all service conditions.

While the data reported above are insufficient to evaluate all the properties of interest in high temperature service, the 12 Cr:1Mo steel appears useful on the basis of the facts so far ascertained. Silicon might be incorporated in the amount of approximately 1 per cent for certain service conditions. In conclusion it is hoped that results of long time creep tests can be reported at a later date.

# Ball Milling for Metal Reclamation

**by G. F. METZ**

*Hardinge Co., Inc., York, Pa.*



*A cross section of a ball mill for reclaiming metals.*

*As the war lengthens our metal-producing mills and foundries must depend increasingly on* industrial *scrap as a major raw material. The reclamation of the metal values in foundry and melt-shop drosses. skimmings, sands, etc. thus becomes a matter of patriotic importance in addition to its natural economic appeal. The application of conical ball mills to such salvage operations in aluminum, zinc and brass mills and foundries is outlined in this article.* —*The Editors.*

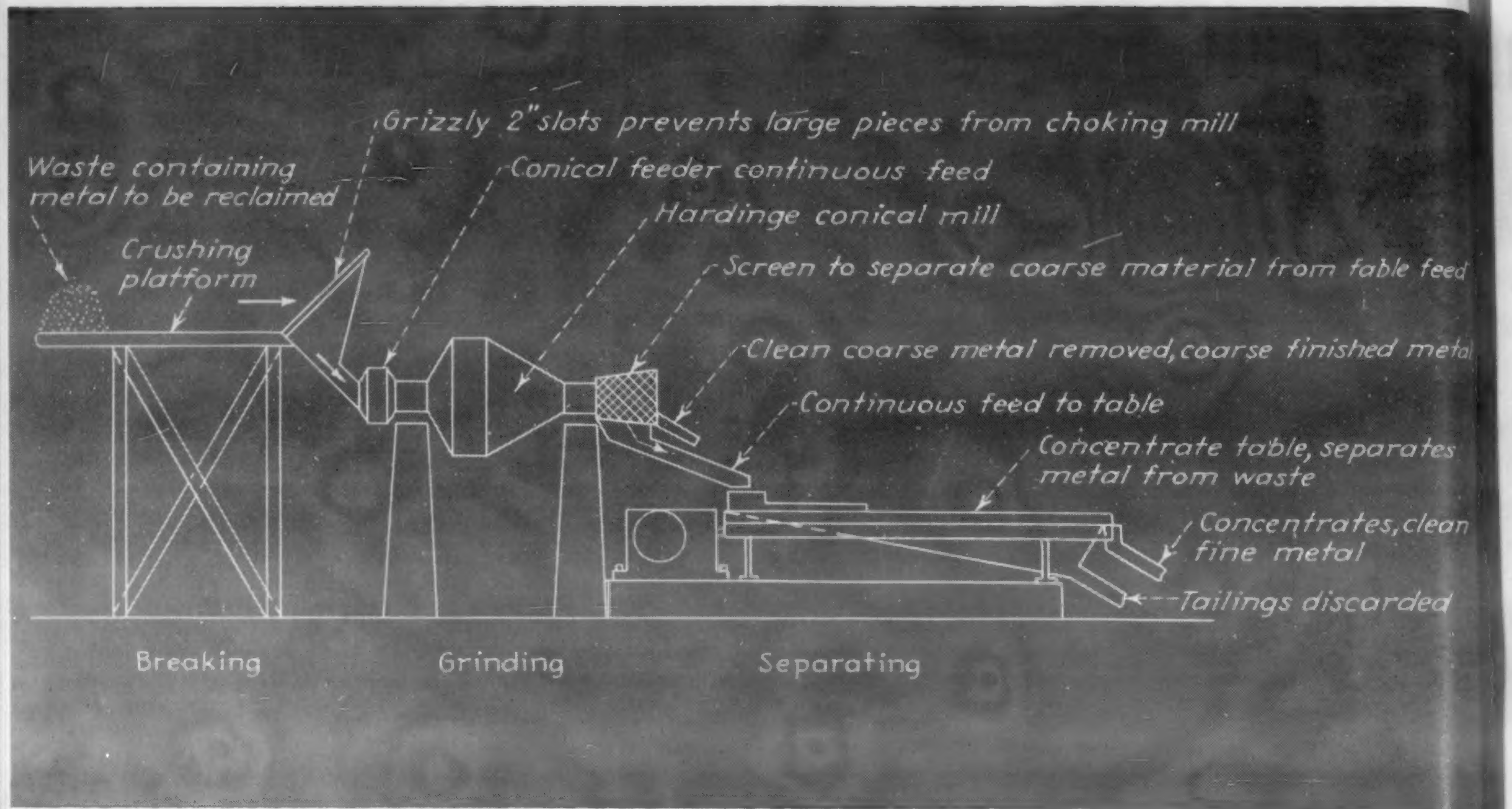
OWING TO THE INCREASING WARTIME DEMAND for metals of all kinds, metal reclamation not only becomes necessary, but in most cases is a patriotic duty with manufacturers who are users of metals in quantities sufficient to cause a sizeable accumulation of scrap.

Starting before the first World War, and up to the present time, conical ball mills of the type discussed in this article have been a most important factor in contributing to the successful processing of metal scrap, slag, dross, skimmings, and floor sweepings, for subsequent concentration of clean metal by wet or dry processes.

Because of the conical shape of this mill, in which both the balls and materials classify themselves according to size, a stage reduction, wherein the energy is proportioned according to the work to be performed, is accomplished. Overgrinding of metal is prevented by the classification action and the rapid passage of material through the mill. No grates or other obstructions hinder the passage of material through the mill, and as a result of the uniform size of product discharged, there is a minimum loss of fine metal in the mill product after screening or concentrating.

## A Typical Layout for Aluminum

Usually a simple and efficient dry processing plant consists of a Hardinge conical ball mill, to the discharge end of which is attached a coarse single or double conical screen, to remove coarse clean metals. A 14-mesh screen is about the limit of this type of screening, and if finer particles of metals are to be reclaimed, it is necessary to screen the minus 14 mesh undersize on a vibrating screen at between 20 and 40 mesh. In more elaborate plants, preliminary




*Flow sheet of a simple wet reclamation plant.*

crushers are used to break up the coarse pieces of slag, or refuse, and instead of attempting to screen on a trommel, a separate vibrating screen is installed following the mill.

The layouts above described are used in a number of primary and secondary aluminum metal plants for recovering clean metal from dross and skimmings. Conical mills are made in sizes of 3, 4½, 5, 6 and 7 ft. dia., for metal reclamation work. Larger sizes are available, but the most popular sizes vary from 3 to 5 ft. in diameter. Capacities vary from 750 lbs. of feed in a 3-ft. dia. by 8 in. long cylinder conical mill to 6 and 7 tons per hr. in a 7-ft. dia. by 22 in. long cylinder conical mill. It is customary, in recent installations, to equip the milling unit with a regulating feeder of the disc type, so as to provide a uniform feed rate to the grinding mill. Feed is conveyed into the mill by means of a drum or scoop feeder depending on the size of the feed.

## Results with Zinc and Brass

The conical mill has also been used to dry crush other metal refuse. At one plant a 4½ ft. x 16 in. Hardinge ball mill is dry crushing coarse zinc skimmings at the rate of 1700 lbs. per hr., the clean metal being retained on a 16-mesh screen, and the oxide going off as an undersize. The mill is charged with 2,000 lbs. of 5-in. dia. and 2,000 lbs. of 4-in. dia. forged steel balls, and consumes 18 h.p., at 35 r.p.m.

At another plant, fine brass is reclaimed from gypsum plaster molds by feeding crushed molds to a 4½-ft. dia. mill, and using the crushed lumps of mold to act as their own grinding media. The soft molds are pulverized quickly in the mill by falling on themselves, and during this operation the mill is subjected to an air suction which conveys the ground gypsum plaster to a cyclone collector set above a storage bin. The fine brass, being much heavier, is discharged by gravity at the end of the mill through an airlock and collected in a barrel. This material is screened on a vibrating screen to remove fine pieces of plaster which were not removed by the air stream. The air from the cyclone collector is returned to the ball mill, thus completing the closed circuit.

Hardinge mills have also been used for years for wet crushing and grinding brass ashes and floor sweepings for the subsequent recovery of clean metal. A simple wet reclamation plant, which gives excellent recoveries, is shown on the flow sheet.

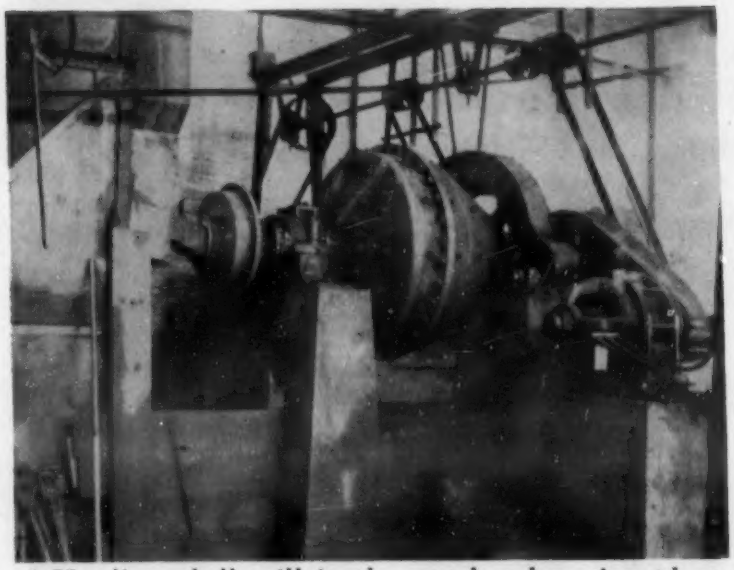
At one plant, treating brass foundry refuse, no concentrating table is used. The mill is equipped with a 6-ft. long, 18-in. dia. screen, attached to the mill discharge. This screen has an 18-in. long section next to the mill discharge, equipped with 20-mesh screen cloth, and the balance is 4 mesh. The ashes and sweepings are fed to the mill by means of a large disc feeder from the hopper set above the mill. This hopper is fed from the floor above. From a feed of 2½ tons per hr., they reclaim approximately 1800 lbs. per hr. of pure metal. The coarse 4-mesh

oversize is collected in a wheel-barrow, and the minus 4 mesh discharges into a pit. Minus 20 mesh material is sent to waste. The mill revolves at 35 r.p.m., and is charged with 5, 4, and 3-in. forged steel balls. A 20-h.p. motor drives the mill through a "V" rope drive.

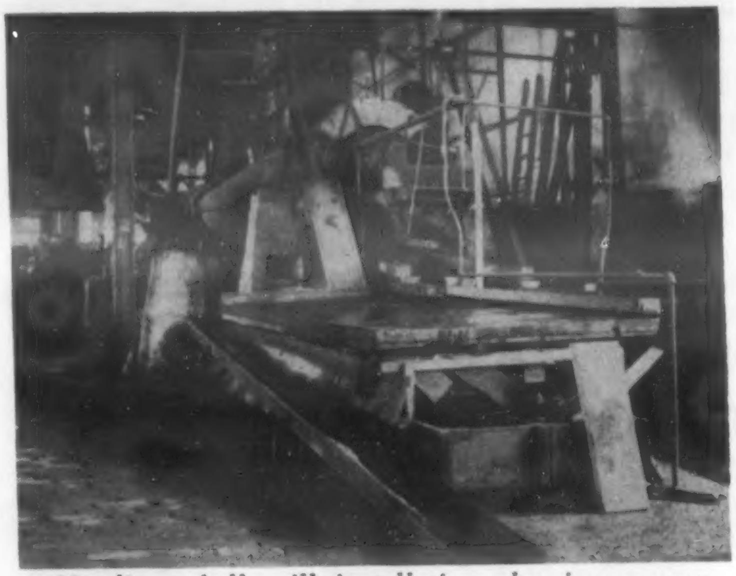
At another plant, a 4½ ft. x 16 in. Hardinge ball mill replaced a grate type cylindrical mill. The Hardinge mill grinds approximately 22 tons per day of 24 hrs. of molybdenum metal slag, from minus 2-in. and finer feed size to all minus 20 mesh. The discharge end of the mill is equipped with 6 mesh screen, from which some coarse metal is reclaimed. The finer product, or undersize from screen, is sent to a concentrating table, which makes a fine concentrate, and the tailings are sent to waste. Prior to the installation of the conical mill, considerable fine metal was lost due to overgrinding of the metal as a result of the grate in the cylindrical mill plugging up with coarse metal, and not allowing the product to discharge. After the conical mill was installed, the product was more uniform, and the loss of fines eliminated.

There are many other special applications of the conical ball mill in metal reclamation. Several installations have been made for the processing of precious metal crucibles, wherein gold and silver values are extracted in subsequent operations. Magnesium metal scrap has been processed in a manner similar to aluminum dross and skimmings.

It is difficult to state the exact size of foundry where it pays to install special reclamation equipment. This depends upon the type of foundry and class of work handled. Equipment for small plants is very simple and requires a minimum amount of attention. The foundry whose waste includes slag, ashes, skimmings, sweepings and sand, aggregating 7 to 10 tons per week, may well look upon the recovery of metal as an attractive commercial proposition, quite aside from the viewpoint of national conservation.



*A Hardinge ball mill in the metal reclamation plant of a large brass foundry.*



*A Hardinge ball mill installation showing concentration table.*

## Refrigerating Aluminum Alloy Rivets—A Correction

Through an unfortunate editorial error in presenting the article "Refrigerating Aluminum Alloy Rivets and Parts" by B. J. Fletcher on pages 1178-1182 of METALS AND ALLOYS for June, certain misleading and inaccurate data, not supplied by Mr. Fletcher, were included.

The "flow chart for aircraft rivet chilling and storage," appearing on page 1182 was added to the article for background illustration by the editors without Mr. Fletcher's prior knowledge. The so-called "annealing furnace" temperature of 850 deg. F. given in the chart is far below the range that will give satisfactory strength in the aluminum alloys under consideration. As Mr. Fletcher states in the article heat treatment must be carried out at temperatures from 930 to 950 deg. F. for alloys A17S and 17S and from 910 to 930 deg. F. for alloy 24S.

Mr. Fletcher, in his letter objecting to our inclusion of the chart in question, points out that the question of the correct temperature for heat treatment, especially of alloy 24S, has been particularly troublesome with some fabricators. There is a tendency to use low temperatures because that practice makes rivets somewhat easier to drive, but material so treated will not develop the required strength.

While the matter of temperature constitutes the principal error in the chart, Mr. Fletcher also mentions that the equipment used for heat treating rivets should be called a "heat treating furnace" and not an "annealing furnace," since the latter designation leads to an entirely erroneous conception as to the operation involved.

Our apologies are offered herewith to Mr. Fletcher and his company, as well as to our readers for allowing this chart to appear without his approval in the article in question. —The Editors

# Plant Engineering and the Co

*In these days of decimated engineering and metallurgical staffs the services of consulting laboratories are being increasingly considered and employed by metal industries plants. Mr. Cady here outlines the type of engineering aid a consulting laboratory can offer, with actual case histories, as a guide to engineering or production executives appraising the possible place of the consultant in their operating picture.*
*—The Editors*

**By EDWIN LAIRD CADY**

THE MODERN PLANT receives uncoordinated metallurgical data from dozens of sources. Information comes in from magazines, convention reports, engineering society publications, conversations with engineers of other plants, and the sales engineers who sell all sorts of industrial products.

The trouble with such information is that it is uncoordinated. From it, management gets in the habit of thinking in terms of picture puzzles, more than half of the pieces of which have not been fitted into the patterns.

## Case of a Large Foundry

The four-year experience of a large foundry and machine shop shows how the consulting metallurgical laboratory can serve as the coordinating agency.

As is quite usual, contact with the laboratory started with a trouble case. The crank on a large air compressor was pitting at the bearing surface. Explanations of this ran all the way from faulty hardening of the crank to sulphur in the lubricating oil, the latter being offered by the engineer who had specified the oil. The metallurgical laboratory found that the steel had been improperly hardened, the bearing clearances on this old style machine had been made too loose, and air had seeped through where the pin had worn a little, allowing the sulphur in the oil to undergo a chemical change and become corrosive.

The foundry had been willing to listen to any one school of thought about what was wrong, and to correct the faulty condition, but the laboratory pointed out that the three factors of hardness, clearances and lubricant all had to be corrected.

This was the start. In a trip through the foundry, the laboratory technician pointed out that the only castings being made were those in which minor flaws were permissible. There was a local market for the special kinds of textile mill roller castings which must be very nearly flawless and free from warp.

The foundry had hesitated to make these castings because they required very close control of operations. But the laboratory had the necessary instruments and equipment to make tight analyses of the scrap fed to the cupola and the pyrometers for rigid control of pouring temperatures, plus the trained technicians to get the process going. Furthermore, the laboratory knew what premiums in prices such castings should command.

The step into flaw-free warp-free castings led the entire plant down a new trail. The machine shop liked to work on such castings, and the product designers liked to build upon them. As a result, one new product after another was developed.

## Expansion of Plant and Personnel

In time, the plant needed new capital. Once more the laboratory was found useful. It made an economic analysis of the patents and processes controlled by the company. On the basis of this, the local bankers laid down their financial plans.

Through all of the first growth period, the laboratory kept in touch with all developments. But as the plant began to settle down into its new grooves, the laboratory cast off its old functions to take on new ones. In the testing department, for example, the laboratory hired a trained metallurgical engineer for the company, helped him to define his duties and to select his equipment, and turned most of the process and materials control over to him.

With the full salaried metallurgical engineer on the job, specifications were refined for the purchasing department, and the plant was fully coordinated to products made exclusively of extra fine castings.

With this done, the laboratory turned its attention to new problems. One of them was the development of new surface finishes for the company's products. Many of the processes available for this were so new that trying them out would be pioneering. The laboratory sent representatives into plants which were experimenting with new surfaces, and into the experimental laboratories of companies which were developing the surfacing products. Recommendations for equipment and methods far advanced over those generally used in the company's field were the result.

A rolling process was needed for forming some of the company's non-ferrous materials. The laboratory found rolling equipment in a near-by plant, and arranged to hire its idle time for the experimental development of the new process.

Here the laboratory did an extreme job of coordination. Sales engineers of rolling mill equipment were called in to tell what they thought should be done, and even to make practical demonstrations on the equipment in use. The men who worked on that equipment all day made their practical suggestions. Production control of the material to be rolled was refined under laboratory direction. The salaried metallurgical engineer made his own investigation

# the Consulting Laboratory

of materials, then worked right with the experimental processes so he was familiar with everything as it developed. As a result, when the company bought its own rolling mill equipment it knew exactly what was needed and what to expect in initial output.

The original trouble shooting function of the laboratory, never wholly ceased. In two cases the laboratory inspected broken equipment, gave testimony before law courts and arbitration committees, and so saved the company the costs of long-drawn-out and bitter legal battles.

This one case shows ten important ways in which a consulting metallurgical laboratory helped a company to grow. These ten include trouble shooting, markets finding, products development, process control, finance, personnel, process pioneering, cooperation with other plants, equipment selection, and reduction of legal difficulties.

## Confidential Results

Perhaps the principal reason why metallurgical or other engineering laboratories do not have more clients which work this closely with them is that the consulting laboratory cannot tell one client what it does for another. Laboratory services are completely confidential. Even a slight discussion of services performed for a client might betray important facts to the client's competitors. The laboratory is deprived of the most powerful weapon in industrial selling—the discussions of results obtained. And this secrecy was never so tight as during the war emergency.

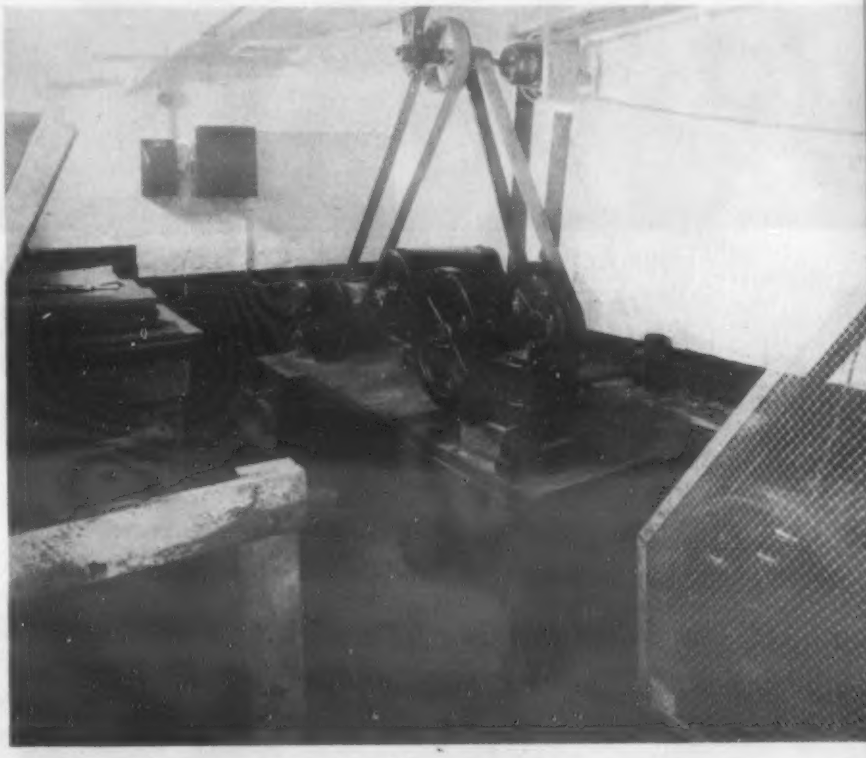
For example, there were recent tests of a graphitized lead-base alloy for bearings. The laboratory had to find the cost of this as compared to the tin alloy metals, for although the shortage of tin makes any good substitute desirable right now, the bearings maker must look forward to peace time markets. Melting points, changes in microstructure upon remelting, and such factors had to be investigated along with field performances. Since this product originally was made abroad, foreign language periodicals had to be read through and translated to reveal any published performance and experience data.

If all that the laboratory learned about bearings could be revealed, then even if the data applying specifically to this one product were kept secret, such a fund of information would be known to be in the laboratory's hands as to bring clients from all sorts of bearings makers and users fields. But one of the most important assets of any consulting metallurgical laboratory to its clients is that such facts are not revealed nor even hinted at.

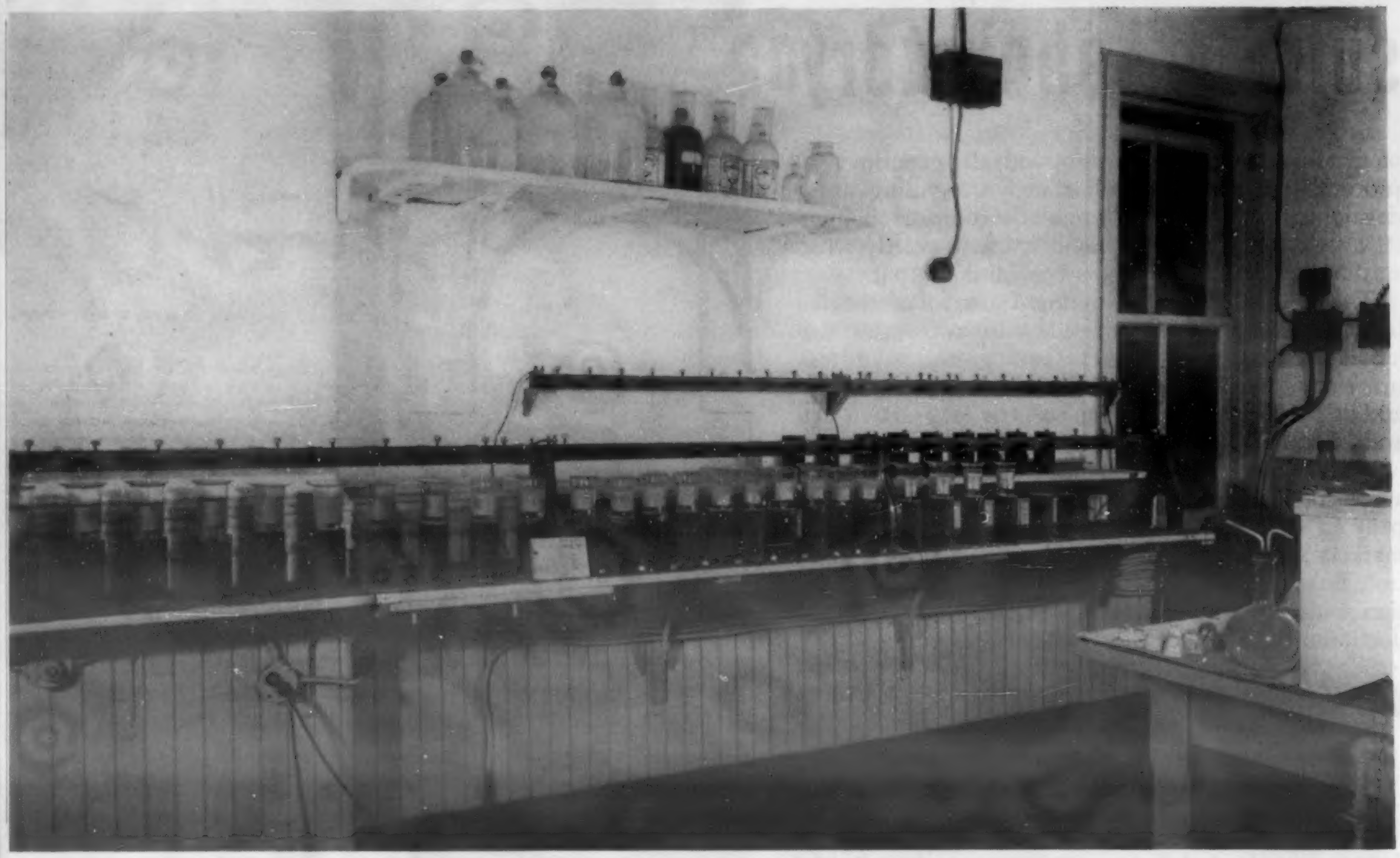
Less dramatic is a chemical analysis made of the well water of a newly built plant. It was feared that if this water contained abnormal amounts of dissolved solids, rusting of the finished parts might be accelerated and subsequent grinding troubles promoted. The water was found to contain enough chlorides, calcium, magnesium, carbonates, etc., to indicate seepage from the near-by Atlantic Ocean. A purifying process was recommended and installed.

No "military secrets" would be let loose if the laboratory were to reveal the name of this client and the type of service performed; nevertheless the fact that the plant has higher control of hardening by doing all of its quenching in specially softened water having exactly controlled analysis, is something for the plant's own sales promotion department to reveal for the sale of the company's products if it so desires, and not for the laboratory to broadcast to attract clients.

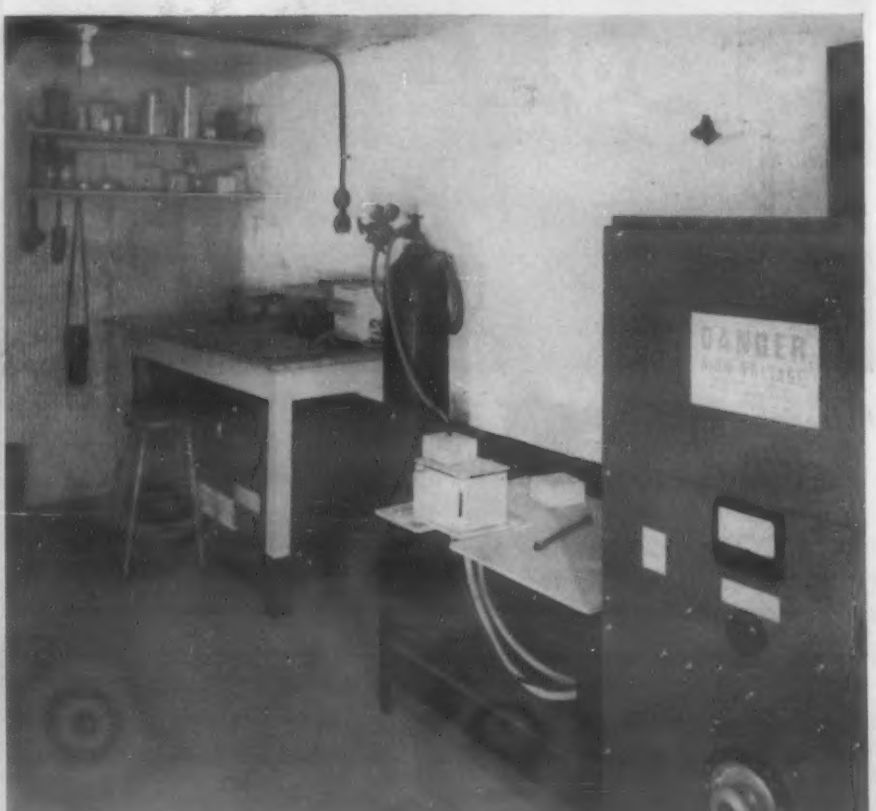
*Furnaces for a variety of products for testing in research work.*



*Pulverizing and grinding equipment for the preparation of ores for assaying and the like.*



*An apparatus for determining copper. There are 24 samples in the rack using 24 platinum electrodes on which the copper is deposited for weighing. There is space for 26 more samples.*



*A small high frequency induction melting furnace, developing 500,000 cycles.*

## Basis of Employment

The basis upon which a consulting metallurgical laboratory is employed also is kept confidential.

Most assignments are "one shot," that is, the laboratory is called in like the fire department whenever there is a serious problem. And this is unfortunate, since it gives the laboratory no adequate time to prepare special methods or devices, forces everything to be done by the laboratory's "specialized-standard" equipment—the equipment would be specialized if owned by the client but is standard for the consulting purposes of the laboratory—and altogether the one shot basis is the most costly and least effective way in which to consult a metallurgical laboratory.

Many more effective systems are available, and one can be found to suit each client-laboratory relationship.

A producer of non-ferrous plated ware uses what might be called the "bulge" system. The laboratory originally made a study of this client's whole set up, and made recommendations for definite projects for future development. Each project requires experimental time in the laboratory, followed by development time in the company's plant, followed again by re-experiment and re-development time. The laboratory is paid a larger fee for the experimental time but a smaller continuing fee while supervising

the development time. Each period of experimental time is called a "bulge" by laboratory and client.

An instruments' maker uses a similar bulge system, but since the projects for his company are less predictable, the continuing function of the laboratory is to study the markets for instruments and also to test competitors' products. The company has learned that the development of a new instrument will mean rapid expansion of production facilities to make it, but the development of a superior one by this company or by a competitor may mean abrupt scrapping of this equipment.

Consequently the laboratory helps to decide what instrument to make, helps to select raw materials and production methods which can be expanded rapidly in use but which can be scrapped with the least pain, and often is the first to predict the scrapping of the equipment or its diversion to other purposes. In an arrangement like this, the continuing month-to-month fee is a larger percentage of the "bulge" than in projects where the arrival of bulges are more predictable.

A metal stamping and forming plant keeps its consulting laboratory fees on a steady month-to-month basis by using an overlapping project method. Projects usually are the development of products from newly evolved steels and other raw materials. The consulting laboratory carries on all experimenting, often to the point of delivering complete new plants or departments in old plants all ready to function. Each major project takes about two years to work out.

The tapering off of laboratory effort on any one project cannot be foreseen. At this tapering off, a new project is commenced, thus keeping the average level of laboratory effort even enough so that a fixed monthly fee is practical, and also keeping level the rate at which new developments are fed to the company's sales promotion department. The war and its contracts produced a decided "bulge" in this relationship, but after a few months this returned to normal and the old relationship was resumed, the effect upon the sales promotion department being the only old factor eliminated.

A maker of engines needs close specifications in steels but is not always able to keep them as close as desired. A continuing relationship on a fixed month-to-month basis has been worked out, by which the consulting metallurgical laboratory inspects each incoming shipment of certain alloy steels, and if the steels are within the acceptance limits of the specifications, establishes a parts-series code to be applied to all parts made of that shipment. This code—its purpose unknown to the operators of the plant's production machines—follows the parts through all steps of each process and is recorded for future checking against field failures or unusual service lives of parts.

If any shipment of steel starts down the production line and then proves either hard to fabricate or completely unsuitable, by the code every part-in-process made of that shipment can be traced and either its production methods modified without modifying them for other lots of steel, or the entire shipment withdrawn from production without performing any further operations after unsuitability is established. Furthermore, when peace returns and the "take what you can get" days are over, this company will be able to lay down steel specifications that will add years of service to its products.

## Control of Methods and Design

Large manufacturers use consulting metallurgical laboratories as extensions of their own facilities. Smaller companies, having no facilities of their own, often find it hard to determine just what the laboratory can best do for them.

One small company pays a fixed month-to-month fee, and has the laboratory make a complete inspection of one axle taken at random from the production line every month. Inspection includes conformance of raw material to specifications, adequacy of hardening, concentricity and parallelism of two round ends which are separated by a relief area, smoothness of finish, adequacy of rust protection, and indications of adequacy and efficiency of other machining operations as shown by microscopic examination of the underground relief area. With the sample part the laboratory takes a copy of the production tickets applying to its production lot, so the complete story of speeds, spoilages, reworks and variations within tolerances can be analyzed.

From all this the laboratory issues warnings of troubles to come, suggestions for changes in tools and methods, suggestions for getting in touch with tool and equipment sales engineers, and the like. One recommendation for a change in grinding wheel grades and speeds with a special inspection station right at the centerless grinders alone has saved the company enough money to pay the laboratory fees for a year.

Another small company employs the consulting laboratory to fix all of the factors of safety in its new product designs. This arrangement is an overlapping assignment one, since the laboratory has to follow through in establishing inspection methods which will assure a product of sufficient accuracy so safety factors can be kept as low as practical.

Such reducing of cross sectional areas by increasing accuracies, is an old story to large companies but a hard one for small factories to achieve. By the use of the laboratory, this company learns how to get profitable accuracies while avoiding unnecessary or impractical ones—how to cash its accuracies while avoiding "accuracy for the sake of accuracy."

In general, the year to year contract for the employment of the consulting metallurgical laboratory is the most profitable one. Most companies think of the consultant only when in trouble, but the most profitable time to call in the consultant is when absolutely nothing seems to be wrong and he can devote his time to building rather than merely to remedying. Continuing contracts allow the laboratory to concentrate on the most profitable lines of product development, and at the same time keep the laboratory instantly available, aware and sensitive when trouble cases must be handled.

(Editorials continued from page 41)

## "Cold" Treating Supplements "Heat"

For several years it has been known that certain beneficial results in metal-working could be attained by the use of extreme cold as a supplement, perhaps, to heat treating, or merely for a mechanical job, such as shrinking a part for fitting purposes. Of course zero or subzero processing was by no means a major tool of production. It isn't quite that yet. But great strides have been made in the last year or two.

Rapid growth has been due, in part, to the necessary skimping in use of alloying elements, of which the National Emergency steels are the best example. Because of the leanness of these compositions it became necessary to give more care to heat treating and auxiliary operations. Refrigeration stepped in and kept quenching tanks, cutting oils and wire drawing compounds from getting too heated. Thus precise control of temperatures as never before resulted.

Again, the development of mechanical refrigeration, by borrowing from the food industry, supplemented the more cumbersome dry-ice method and made the chilling process, for whatever metal-working purpose, more convenient and efficient.

For another job it was found that extreme cold could do a better job in an application where heat had been used formerly — in shrink fits. Previously, where two parts were to be joined in a close fit, involving an insertion, the recessed part was expanded by heat while the inserted part was left at room temperature, a "press fit" finally accomplishing the joining. However, this often was accompanied by warping, marring and use of expensive machinery. The more modern method would appear to be to shrink the opposite part by subzero cold, leaving its companion at room temperature. Chilling methods applied to shrink fits are described in an article in this issue.

Alternate exposure to cold and heat "seasons" certain steels, such as those used in gages, thereby stabilizing them against creep and distortion. Another important application is to prevent aluminum alloy rivets of certain analyses from age hardening until ready to be driven, as was explained admirably by B. J. Fletcher in the June issue of METALS AND ALLOYS. Refrigeration of welding electrodes is said to prevent "pick-up" and makes many more welds than usual before redressing the electrode.

Yes, cold treating may force a niche for itself in metal processing alongside its older companion, heat treating. —H. A. K.

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# A Few Chuckles

### Alloy Steel Instead of Nickel Steel!!

In the November issue of *Hunting and Fishing,* we find the following question in the Questions and Answers department:

> "Is a nickel rifle barrel any better than any factory tested barrel for Hi-explosive powder?"
>
> The answer which was published is as follows:
>
> "Nickel steel rifle barrels are considerably inferior in durability, and no better in point of accuracy, to the proof steel barrels made by the Winchester Repeating Arms Co. and the Remington Arms Co., Inc. The proof steel barrels are an alloy steel that resists erosion much better than nickel steel, as well as having longer accuracy life. Even the service rifles used in the Army and Navy have barrels of alloy steel instead of nickel steel."

### Ultra-Refining

*To the Editor:* Here's one for the "Chuckles Department." Quoted from the "New York Times," Sunday, Dec. 20, 1942, Science News in Review, Sponge Iron, by Waldemar Kaempffert, and contained in a four-page brochure of the State of North Carolina, Governor's Office, J. Melville Broughton, Governor of North Carolina:

> "But the coal contained such impurities as carbon, sulphur, and phosphorous, and these had to be removed in supplementary processes."

HAROLD L. WALKER,

Head, Department of Mining and Metallurgical Engineering
Univ. of Illinois
Urbana, Ill.

### Tool (?) Steel

*To the Editor:* I think that the following "ad" from a recent Sunday issue of the *New York Times* might be of interest to some of the readers of your "Chuckles":

> TOOL STEEL
>
> Chromium 1.39, carbon 0.33, tungsten 0, nickel 0.
> 5 pieces approximately ¾ in. by 9 in. by 60 in. Utility Elevator Service, 34 Jumel Place, New York.

H. S. BLUMBERG
Metallurgist

M. W. Kellogg Co.
Jersey City, N. J.


# TODAY copper fights on the global fronts

Today the copper industry is working all-out to win the war. No copper is available for anything else. But post-war planners with specific problems in metals are referred directly to the Revere Executive Offices in New York.

**REVERE**

**COPPER AND BRASS INCORPORATED**

Founded by Paul Revere in 1801

*Executive Offices: 230 Park Avenue, New York*


## NICKEL AIDS THE AUTOMOTIVE INDUSTRY

## *to KEEP 'EM ROLLING!*

Using ingenuity and "know-how" born of long experience, automotive engineers designed the phenomenally successful transport equipment that now speeds the United Nations on the road to Victory.

Built to take punishment far above peacetime requirements, these specialized military vehicles are being produced in quantity by the mass-production methods that have amazed the world. From North Africa to the South Pacific, these trucks, jeeps, tanks and half-tracks have repeatedly met wartime demands for stepped-up performance.

This kind of engineering-thinking pioneered tne appiication of Nickel alloyed materials. Now, when uninterrupted operation is so vitally important, the continued and widespread use of Nickel is clear evidence of its many advantages.

In steering knuckles or differentials, in forged gears or cast blocks, a little Nickel goes a long way to provide essential dependability. It improves strength/weight ratios, increases wear and corrosion resistance, imparts toughness, and assures uniform properties of the other metals with which it is combined.

Today, maintenance crews on far-off battle fronts are learning what metallurgists and engineers here long have known . . . that, properly used, Nickel aids to "keep 'em rolling."

For years the technical staffs of International Nickel have been privileged to cooperate with automotive engineers and production men . . . men whose work is now so necessary to the Nation. Counsel, and printed data about the selection, fabrication and heat treatment of ferrous and non-ferrous metals is available upon request.

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

*** Nickel ***

*For lists of current publications, please address Technical Library Service*

**THE INTERNATIONAL NICKEL COMPANY, INC.,** *67 Wall St., New York, N. Y.*

# Tin Bronzes

### A Digest of Common Specifications

*This is a continuation of the special series of "File Facts" pages on copper alloy specifications. Tabulations have already appeared on Coppers (May), Brasses (May) and Leaded Brasses (June). Subsequent installments will cover Leaded Tin Bronzes; Special Bronzes; and Miscellaneous Copper Alloys. The information is assembled chiefly from ASTM Standards, 1943 and from the SAE Handbook, 1942 edition.*

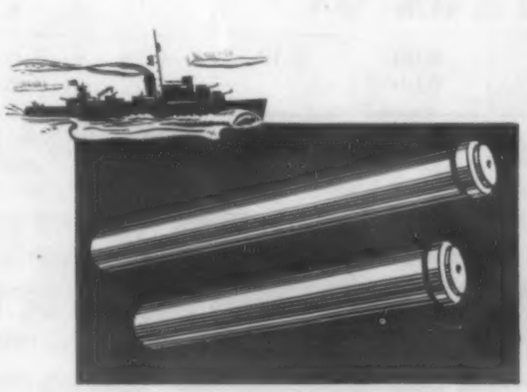
| Name | Characteristics and Uses | Specifications | Form or Grade | Composition, Per Cent | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Cu | Sn | Pb (max) | Zn (max) | Others |
| **Wrought copper-tin alloy** | This alloy has good wear resisting properties. | ASTM B100, Type A | Rolled copper-alloy bearing and expansion plates for bridges, etc. | Rem. | 3.8 min. | — | — | P 0.5 max. |
| **Phosphor bronze** | Adaptable to forming, drawing, stamping, bending, etc. Used to make springs for electrical equipment. | ASTM B103, Grade A | Phosphor bronze sheet and strip | " | 3.50-5.80 | 0.05 | 0.30 | P 0.03-0.35 |
| | | SAE 77, Grade C | " | | 7.0-9.0 | 0.05 | 0.20 | P 0.03-0.25 |
| | | ASTM B103, Grade D | " | | 9.0-11.0 | 0.05 | 0.20 | P 0.03-0.25 |
| | Hard, sand cast alloy. | SAE 65 | Phosphor gear bronze | 88.0-90.0 | 10.0-12.0 | — | — | P 0.10-0.30 |
| | Grades A, C and D may be used for functional machinery parts, such as bolts, gears, etc.; and the B1 material is suitable for screw machine products. | ASTM B139, Grade A | Phosphor bronze rods, bars, shapes | Rem. | 3.50-5.80 | 0.05 | 0.30 | P 0.03-0.35 |
| | | ASTM B139, Grade B1 | " | " | 3.50-5.80 | 0.80-1.25 | 0.30 | P 0.03-0.35 |
| | | ASTM B139, Grade C | " | Rem. | 7.00-9.00 | 0.05 | 0.20 | P 0.03-0.25 |
| | | ASTM B139, Grade D | " | | 9.00-11.00 | 0.05 | 0.20 | P 0.03-0.25 |
| | The three grades of alloys under this specification are used for spring and general purpose wire. | ASTM B159, Grade A | Phosphor bronze wire | " | 3.50-5.80 | 0.05 | 0.30 | P 0.03-0.35 |
| | | ASTM B159, Grade C | " | " | 7.00-9.00 | 0.05 | 0.20 | P 0.03-0.35 |
| | | ASTM B159, Grade D | " | " | 9.00-11.00 | 0.05 | 0.20 | P 0.03-0.25 |
| | | SAE 81 | " | " | 4.00-6.00 | 0.10 | 0.20 | P 0.03-0.40 |
| **Tin bronzes** | These are two regular and two alternate** alloys used for steam and valve castings, structural parts, bushings and bearings. They are tough, fine-grained, corrosion- and pressure-resistant. | ASTM B143, Alloy No. 1A | Tin bronze sand castings | 86.00-89.00 | 9.00-11.00 | 0.03 | 1.00-3.00 | Ni 1.0 max. |
| | | SAE 62 | Hard bronze castings | 86.00-89.00 | 9.00-11.00 | 0.20 | 1.00-3.00 | — |
| | | ASTM B143, Alloy No. 1B* | Tin bronze sand castings | 86.00-89.00 | 7.50-9.00 | 0.03 | 3.00-5.00 | Ni 1.0 max. |
| **88-10-2 composition "G" gunmetal** | The 88-10-2 alloy is used for valves withstanding pressures of 1000-4000 per sq. in., and for unlubricated severe service bearings. | ASTM B143, Alloy No. 2X | " | 86.00-89.00 | 7.50 9.00- | 1.00 | 3.00-5.00 | Ni 1.0 max. |
| | | ASTM B143, Alloy No. 2Y | " | 86.00-89.00 | 7.50-11.00 | 0.60 | 1.00-5.00 | Ni 1.0 max. |
| **88-8-4 modified "G", etc.** | 88-8-4 is used for valves operating at pressures of 500-1000 per sq. in., and for service less severe than for 88-10-2. | ASTM B30, Alloy No. 1A | Copper-base alloys in ingot form for sand castings | 87.00-89.00 | 9.50-10.50 | 0.25 | 1.50-2.50 | Ni 0.75 max. |
| | | ASTM B30, Alloy No. 1B | " | 87.00-89.00 | 7.75-8.50 | 0.25 | 3.50-4.50 | Ni 0.75 max. |

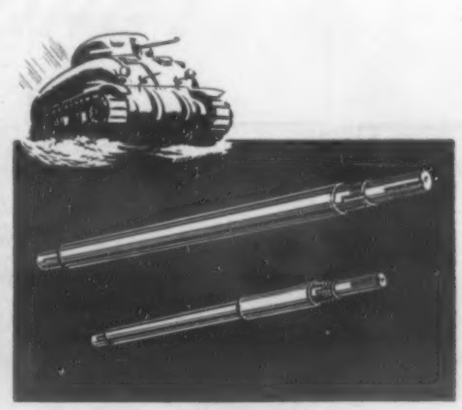
* *Note: ASTM B143, Alloy 1B, is to replace ASTM B-60*

** *The Emergency Alternate alloys 2X and 2Y are intended to expedite procurement as they permit wider use of secondary metal scrap; alloy 2X is suitable for large bearings and structural parts and 2Y alloy is used for small bearings and bushings that must be corrosion resistant.*

*Compiled by Robert S. Burpo, Jr.*







# Induction Heating Equipment

Induction heating, although hardly new to engineering, has in the past few years been so widely and diversely applied that it has almost the effect of a new process. These new applications have been in part made possible by new developments in equipment, such as the vacuum tube oscillator. The earlier use of the induction furnace for the melting of metals has been widened by the use of the new high frequency spark gap converters and vacuum tube oscillators to include hardening, annealing, vacuum-heating and melting, sintering, stress relieving, soldering and brazing, and many others.

The principle of induction heating is best illustrated by considering the effect upon a round steel bar placed in a wound coil carrying alternating current. The magnetic flux, building up and collapsing with the change in value of the coil current, induces a current in the bar, which heats the surface of the bar to the critical temperature within a few seconds. This surface zone then loses its magnetism. Successive underlying zones are heated and lose their magnetism likewise.

This surface effect offers the engineer the opportunity to harden a steel article to a definite depth. At the same time (under certain conditions) the temperature may be built up throughout the piece, permitting use of the process in forging or sintering operations.

### Types of Alternators

There are four general types of alternators used to produce the current used in induction heating. Bearing in mind that each of these is capable of specialized applications outside of its principal field, and that the classifications given here will overlap in such uses, they may be grouped as follows:

| Type | Most common frequencies | Uses |
|---|---|---|
| Direct Connected | 50-60 cycles | Melting of metals, particularly brass and aluminum. |
| Motor-Generator Set | 1000-3000 cycles | Melting of metals, heating billets for forging, etc. |
| Spark-Gap Oscillator | 100,000-300,000 cycles | Heat treating of small parts, soldering, brazing, etc. |
| Vacuum Tube Oscillator | 100,000-1,000,000 cycles | Heat treating, annealing, sintering, soldering, brazing, etc. |

### Direct Connected

Induction furnaces for metal melting may be direct connected, standard-frequency powered, with three phase current for the larger units or single phase supply for smaller installations. In these furnaces the power supply is connected to the primary of a transformer, while the charge itself becomes the secondary. A battery of capacitors correct power factor so that a high efficiency is obtainable. As the unit is self-contained a minimum of floor space is required. High power transfers are possible.

This type of furnace is widely used for melting of non-ferrous metals, particularly brass and aluminum, because of its low metal loss.

### Motor-Generator Set

The motor-generator set, which has been developed to supply power at frequencies as high as 15,000 cycles per second, can pass high wattages, and is especially useful in the heavy duty field. It has been the source of current for large melting furnaces, as well as for some of the smaller heat treating installations. Frequency limitations prevent its economical use in heating of copper, aluminum, brass, and similar low-resistance metals, or for rapid heat treating of irregular objects. It provides quick, "clean" heating of large quantities of metal, with opportunities for atmosphere control.

### Spark-Gap Converter

The spark-gap converter offers much higher frequencies and a more compact installation. The converter consists of a high reactance transformer, a discharge gap, and a bank of capacitors connected to a heating element, or inductor. The transformer charges the condenser to a high voltage. The condenser then discharges through a spark gap and coil to set up oscillations in the current, which produce the changing field in the inductor coil.

Because of the high frequencies available, the spark-gap type of machine can be used to heat aluminum, copper, and other high-conductance metals; surface or other localized heat treating; silver soldering; brazing; heating of otherwise inaccessible sections of a piece, and many other applications. Its most serious drawback is the difficulty of transmitting power in excess of about 35 kw. Small to medium sized installations use this type to best advantage.

The inductor may be especially shaped for a particular piece of work, especially if the piece be irregular in shape. A coil of a given number of turns of small copper tubing, through which water is circulated, is a common form of inductor. A cast inductor, in which a water spray is provided for, permits heating and hardening to be done in the same coil.

### Vacuum Tube Oscillator

Vacuum tube oscillators are the newest in the field of induction heating. They provide the possibilities of extremely high frequencies and also of large power output. Such equipment is based upon the resonant circuit with triode tube and grid feed-back. A small amount of the output energy is bled off and fed back to the grid circuit, causing the tube circuit to break into oscillation. Control of circuit inductance and capacitance gives control of the frequency at resonance. The frequency control is quite flexible, and the range of possible frequencies very wide — the circuits may be designed to frequencies of a few cycles per second, or to 15,000,000 cycles or higher.

The range of applications is correspondingly wide. The controls may be used with various types of heat treating furnaces, with special heat treating equipment, for sintering, soldering, brazing, annealing, stress relieving, experimental work, and so on.

### High Frequency Heating of Non-Metals

Although they are *not* induction heating, interesting and widely publicized applications of ultra-high-frequency heating are in plywood fabrication, in the production of artificial fever in the medical field, electronic stitchers for plastics, etc. In these uses, frequencies of several million cycles are used, and the part being heated is a non-conductor and hence carries no induced electric current.

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Induction heating makes possible the internal hardening of diesel engine sleeves, gun parts, airplane engine cylinder barrels, etc. In some applications where inside and outside surfaces are similarly and simultaneously treated, the hardness of the inner surface may be approximated by testing the outer and accessible surface. Parts in which a sharply limited surface must be hardened while the remainder of the piece must remain soft can be treated by induction heating. Heat treating furnaces to heat and quench parts semi-automatically have been designed to use induction heating, scale-free work resulting. Soldering and brazing operations are often more rapidly and cleanly done by induction heating than with a torch, and the simplification permits the use of less-skilled labor.

The considerable savings in time, along with the better, more uniform work produced, justify the cost of the necessary induction heating equipment on most jobs.

*Compiled by Kenneth Rose*

NUMBER 18

PROCESSES AND PROCEDURES
Machining

GETTING MAXIMUM PRODUCTION FROM

# High Speed Steel Tools

High speed steel can often be made to go farther by employing several devices. Five general methods for getting the most out of cutting tools and stretching the available high speed steel are:

(1) The selection of the right tools for the job, and the proper use of these tools in doing the job.
(2) Grinding the tools so that the maximum number of parts per grind can be obtained.
(3) Improvements and variations in heat treatment.
(4) Repair and salvage of worn and/or broken tools by such methods as chromium plating or brazing.
(5) Using high speed steel tips (instead of solid tools) in lower alloy steel shanks.

The selection and application of tools is too big a subject for discussion here. The assumption can be made that the tool has been properly selected, and this discussion will be concentrated on the last 4 items of the above list.

### Wheel Dressing

An example of the influence of Item 2 on the longevity of a cutting tool is briefly summarized below. The cutting tool used as an example in Table I was a helical plain milling cutter approximately 6 in. in diameter by 13 in. width of cutting face and was resharpened three times by grinding with the same abrasive wheel each time; merely by improving the wheel dressing technique the number of pieces per regrind was increased noticeably.

*Table I*

| Test No. | Grinding Technique | Number of work-pieces machined before regrinding was necessary |
|---|---|---|
| 1 | The correct wheel was used, but it was dressed with a stick, grinding an irregular cutting edge on the tool. | 20 |
| 2 | Same wheel used, but dressed with a dull diamond. | 60 |
| 3 | Same wheel used, but dressed with a sharp diamond carefully adjusted. | 200 |

### Surface Finish

Not only is the regularity of the cutting edge (as effected by a correctly dressed grinding wheel) an important factor in increasing tool life, but the actual surface finish produced on the cutting edge by the sharpening operation has a profound influence. This influence is shown in the following summary in which is tabulated the percentage increase in tool life due to finishing the cutting edge with a very light cut (about 0.001 in.) after removing 0.003-0.005 in. with a roughing wheel (see Table II).

*Table II*

| Tool | Material Cut | Percentage Increase in Tool Life |
|---|---|---|
| 8-pitch gear tooth cutter | steel | 9 |
| 12-pitch gear tooth cutter | cast iron | 208 |
| 6 in. Lovejoy mill | —— | 400 |

From the figures given in Table I and II it can readily be seen that by sharpening the cutting tool with an abrasive wheel that is properly dressed and using the correct grade of roughing and finishing wheels (so that as high a surface finish as is economically possible is maintained) the useful life of high speed steel cutting tools may be prolonged considerably.

### Heat Treatment

When discussing factors affecting tool life, the heat treatments applied to high speed steel tools should also be considered. The complete elimination of both decarburization and oxidation in the hardening operation is of prime importance, for if either occurs, the resulting skin must be removed by grinding. This means less grinds per tool as well as a lower quality tool. Protective atmospheres are used that furnish fairly complete protection to high speed steels when properly employed.

Another method of protecting tools during hardening is to heat them in a heat resisting metal box containing enough fused boric acid to cover the tool. When removed from the box, the film of molten salt clinging to the tool protects it during exposure to air. This method (using fused boric acid) is especially helpful when only a few tools are hardened at a time; for large lots, the protective atmosphere is more efficient.

Adequate tempering is known to aid in increasing tool life. For example, a "double tempering" treatment (*i.e.* heating the tool to 1050 deg. F. for 2½ hrs. followed by air cooling to room temperature, and then repeating this cycle) will generally increase both the tensile and torsional-impact strength approximately 10 per cent, with a reduction in hardness of about ½ point Rockwell "C," as compared with a single 5-hr. tempering operation at the same temperature. This increase in strength properties is due to a greater freedom from residual internal stresses and is very beneficial when the tool must withstand intermittent cuts or other severe duty where failure by breaking is likely to occur.

Yet another method of improving tool performance and, therefore, increasing the number of pieces machined per grind is suggested in the following outline.

(1) Harden the tool in the usual manner.
(2) Temper at 1050 deg. F. and air cool.
(3) Heat tool in a molten salt bath (composed of a 50-50 mixture of potassium and sodium cyanides) at 1050 deg. F. for 30 to 60 min., depending on the size of the tool.
(4)9ir cool.

By this method, a thin case (less than 0.001 in.) is built up, which gives added wear-resistance to those surfaces of the tool subject to erosion by chip-flow.

### Chromium Plating Tools

A similar purpose (preventing erosion) is served by a thin chromium plate deposited over the hardened tool, as the plate has a low coefficient of friction. However, hydrogen embrittlement must be guarded against. This use of chromium plating does not have a very wide application; as a method of building up worn or defective tools it has a much greater range of application.

Tools (such as gages, punches, dies, etc.) that have been subject to enough wear to destroy their accuracy, and those that have been ground oversize, can be plated with chromium and have their usefulness restored. For this type of work

*(Continued on page 79)*

NUMBER 18 (Continued)

GETTING MAXIMUM PRODUCTION FROM HIGH SPEED STEEL TOOLS

the possible variation in plate thickness is from less than 0.001 in. to 0.025 in.; a thickness of 0.001 in. to 0.002 in. has been found to be the best generally, and usually need not be finished by grinding. The time required to build up a coating of chromium is about 1 hour per 0.001 in. Another advantage to chromium plating twist drills (even new ones) is that (besides decreasing the wear on the tool and prolonging its life) the dimensional accuracy of drilled holes is such as to sometimes allow omission of reaming operations.

Table III summarizes some of the uses of chromium plating as a means of increasing tool life and of salvaging worn or defective tools.

*Table III. Chromium Plating of Tools*

| Type of tool | Thickness of plate in inches | Surface plated | Reason for plating and remarks |
|---|---|---|---|
| Drawing die | 0.001 | ID | No grinding after plating; life between grinds increased from 2-5 hrs. to 1-2 days. |
| End mill | 0.005 | ID | The ID was accidently ground oversize — tool salvaged by plating and grinding ID to size. |
| Form cutter | 0.003 | ID | The ID was ground oversize — tool salvaged by plating and grinding ID. |
| Forming punch | 0.001 | OD | No grinding after plating — plated to increase tool life. |

Note: Cost of plating in first and fourth items above was approximately \$2.00-\$3.00.

These plating operations must be followed by heating to 350 deg. F. in an oil bath for about an hour in order to prevent hydrogen embrittlement.

*Table IV. — Steps in a Tool-brazing Repair Job*

| Step No. | Operation |
|---|---|
| 1 | Chamfer edges of breaks on both sides so that about 1/16 in. width of surface would abut when joined. |
| 2 | Clean surfaces to be joined using carbon tetrachloride. |
| 3 | Apply flux to surfaces to be joined. |
| 4 | Clamp broken pieces in a holding fixture that has been previously warmed to 400-500 deg. F |
| 5 | Braze joints on one side; unclamp and complete the joints on the opposite side. |
| 6 | Cool cutter slowly by burying in lime for about 24 hours. |
| 7 | After regrinding, cutter is ready for use. |

Broken and cracked high speed steel milling cutters and similar tools can be simply repaired by using a special high-strength low-melting brazing alloy. For example, the steps followed with one such alloy (Castolin No. 16 of Eutectic Welding Alloys Co.) in repairing a ½ in. x 6 in. diameter high speed steel staggered tooth side milling cutter (cost, new, about \$30.00) that was broken through the keyway into two pieces are listed in Table IV.

The actual time for steps 1 through 5, above, was 18 minutes, and the reduction in hardness caused by the brazing operation is usually less than 1 point Rockwell "C." Such brazed joints made with this proprietary rod seem to have strength properties at least equal to those of the base metal.

### Tipped Tools

Although not a means of increasing tool life, the use of tipped tools does permit getting many more tools out of a given amount of high speed steel, so it merits careful consideration.

As a means of saving high speed steel, tipped tools are highly advantageous. For this purpose 0.40-0.60 per cent carbon chisel steel shanks have proven satisfactory, and in a tool weighing 18 lbs., only a 2 oz. tip need be of high speed steel, which represents a substantial saving. These tips may be secured to the shank by several methods; two of these methods that have been used with high speed tips are given in Table V.

Additional data on tool-tipping will appear in an early issue.

*Table V. — Some Tool-tipping Methods*

| Name of Method | Description of Operation | Remarks |
|---|---|---|
| Braze-hardening | The tip end of shank is heated to 2150-2250 deg. F., causing a strip of copper between the tip and shank to melt (melting is complete at hardening temperature) — thus, the tip is brazed to the shank and hardened as with a solid tool. | Especially adapted to use with molybdenum high speed tips. The shank is partially hardened, which increases its strength. |
| Braze-tempering | The hardened tip is brazed to the shank, using a silver solder (m.p. 1350 deg. F.); this partially tempers the tip, which must be further tempered at 1050 deg. F. | This type of brazing must be done very quickly as m.p. of the brazing alloy is above the softening point of the tip. |

*References*

Data for the Tables were obtained from the following sources:

Table I.—"Getting the Most Out of Cutting Tools", by R. T. Wise, *The Tool Engineer*, Jan. 1942, pp. 47-53.

Table II.—"Refined Surface Finishes as Applied to Regrinding of Metal Cutting Tools," by V. H. Ericson, *Grits and Grinds*, (The Norton Co.) Vol. 30, No. 5.

Table III.—"Hard Chromium Plating for Wear Resistance and Salvage", by S. H. Brams, *Iron Age*, p. 56, Feb. 4, 1943.

Table IV.—"Low Temperature Joining for Production and Repair", by Robert S. Burpo, Jr. Soon to be published in METALS AND ALLOYS.

Table V—"High Speed Steel Tipped Tools", by Lement and Kennedy. *Steel*, Feb. 15, 1943, p. 90.

*Compiled by Robert S. Burpo, Jr.*

# METALLURGICAL ENGINEERING

# shop notes

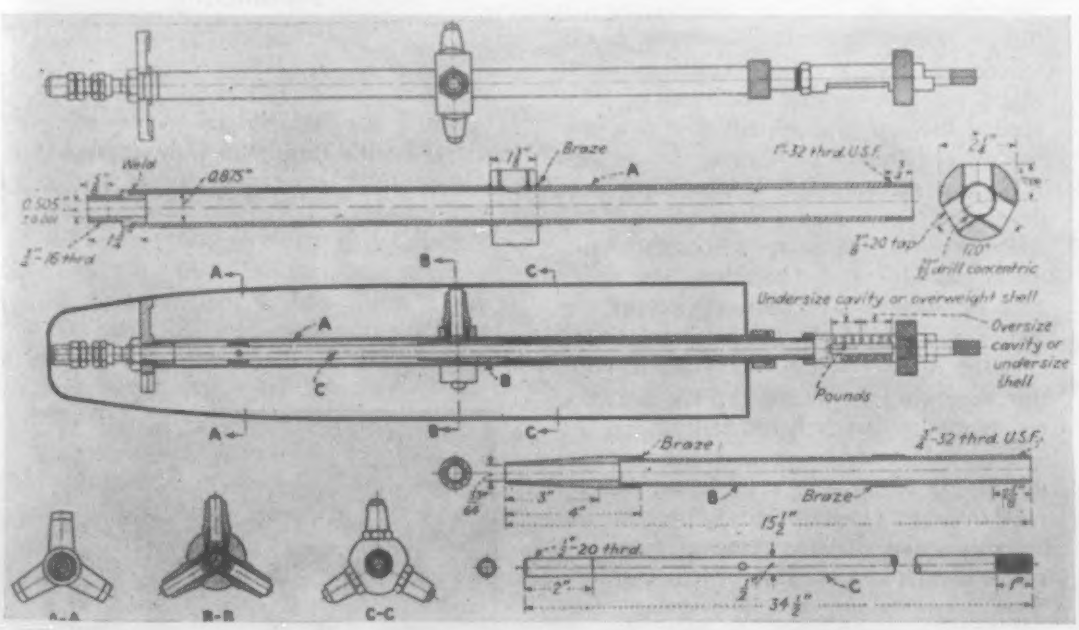
## Ingenious Shell Cavity Gage

*by Frank Speke and Clarence Reynolds, Willys-Overland Motors*

A new shell cavity gage for measuring 155-mm. shells caused rejection of only 200 shells out of 1,000,000 whereas prior to the invention of the device, the rejections were proceeding at the rate of 3,500 units in 1,000,000. First devised at the plant of Willys-Overland, by the authors of this article, it is now being used by nine other manufacturers.

Willys-Overland was the first to make 155-mm. shell with mass production using the forge method and employing multiple die forging presses, multiple spindle turning machines and other heavy-duty machines employing tungsten carbide tools. Willys-Overland found the most difficult problem was the shell cavity that controls all the dimensions of the shell. It is not possible to hold the forged cavity to close tolerances. Variations in dimensions of the cavity made it hard to maintain a finished weight of the shell that would pass rigid weight inspection.

The cavity consists of a straight portion that blends into a taper portion, both of which have their proportionate bearing on the ultimate weight of the finished shell. Our new gage consists of a 3-point bearing in the taper portion, the diameter of which is measured by a sliding rod projection to the bottom of the cavity.




The cavity's straight portion is measured by three expanding pins operated by a taper cone, which is concentric with the depth rod of the taper portion. The cone's taper is such that it has the correct proportion in weight between the straight and taper portions of the cavity. The tube operating the cone, at its outer end, carries a head, which is marked off in division of weight.

The operating rod that checks the taper portion carries the index line. Thus, the weight of the taper and the straight portion are compounded into the correct dimensional weight of the entire cavity. Simply, the gage measures the plus or minus weight of the shell cavity.

The weight divisions of the gage are painted with dots of six different colors, and the gage is applied as the shell forging comes from the forge division. The operator, in sliding the gage into the cavity, can tell at a glance at the indicator which color the index line records, whereupon the shell is marked with the appropriate color with paint. This guides the operator of the "nosing press" in bringing the shell to the desired finished weight. If the cavity is too large, metal is "pushed" back into the cavity. All such care is necessary for absolute accuracy in firing.

A detailed drawing illustrates the gage and shows how it is applied to the shell cavity.

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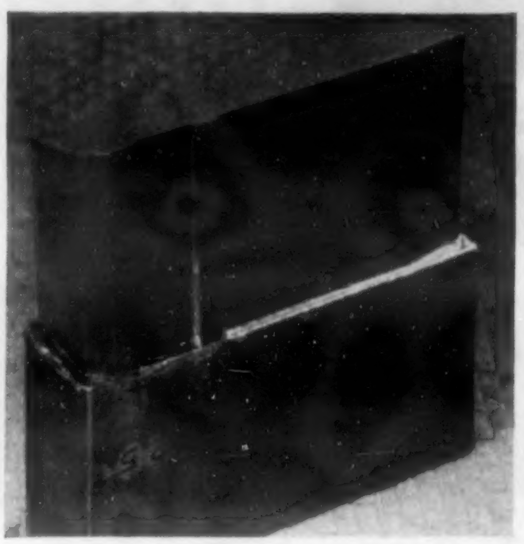
*The use of the largest electrodes possible on each type of fabricated job was one reason for maximum production and, hence, attainment of the Army-Navy "E" by the Commercial Shearing & Stamping Co., Youngstown, Ohio. A 3/8-in. fillet weld on 1/2-in. mild steel plate, formerly welded with 1/4-in. electrode at 40 ft. per hr. arc time, is now done with a 3/8-in. electrode at 95 ft., thereby increasing arc time efficiency from 40 per cent with 1/4-in. rod to 55 per cent with a 3/8-in. electrode. A 1/4-in. fillet on 3/16-in. plate, formerly welded with a 3/16-in. electrode at 8 in. per min. arc time, can be accomplished with 1/4-in. rod at 14 in. per min. arc time.*

—R. V. Proctor, Commercial Shearing & Stamping Co.

## Brazing Discarded Cutters

Only a small sliver of 18-4-1 high-speed steel now remains when the tool is finally discarded at the Armstrong Cork Co., Lancaster, Pa., whereas they were



previously scrapped when worn to 1½ in. from the original 2⅞ in. The worn high-speed steel is joined to shanks of 10-20 carbon steel by silver brazing, the tools being used to make 20-mm. armor piercing shot. Now the company has increased production from an average of 25,000 to 50,000 per each cutting unit.

The cutting tools are used on 8-spindle, Conematic turning lathes. Armstrong buys 18-4-1 steel in bar stock. After cutting to length, the tool must be machine formed, heat treated, ground to precise specifications, and, finally high-speed-cased, the last operation increasing tool life from 50 to 100 per cent.

Silver brazing thus saves hundreds of man-hours by putting again into service what had been thrown away. The reclaimed tool retains its original temper and contour. It was found, too, that the tools still withstand cutting pressure after brazing. Armstrong figures that the saving is between 56 and 78 per cent.

*Armstrong Cork Co.*

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*A problem in a Mansfield, Ohio plant was to salvage bent and warped condenser plates used in radio assemblies. It was found that all previously-scrapped materials could be straightened by clamping the pieces between steel plates and subjecting them to 400 deg. F. for 1 hr. and 15 min.*

*—J. M. Carr and I. J. May, Westinghouse Electric Mfg. Co.*

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## Steel Cartridge Case Varnishes

*by W. H. Stephens,*
*Roxalin Flexible Finishes, Inc.*

Part of the success of steel cartridge cases, as a substitute for brass, has been the film of varnish, not exceeding 0.0005 in. thick, which helps prevent the case from sticking in the gun at rejection time. The coating is designated as Ordnance Dept. Butative Specification AX S-736, and it is possible that what has been learned with this varnish may be applied to peace-time production.

The coating on the inside of the cartridge case must prevent reaction between metal and chemicals in the powder of the charge; the outside coating must protect against atmospheric corrosion and permit the case to function satisfactorily when fired.

The inside coating must resist acetic acid, ammonium hydroxide, toluol, alcohol and ethyl ether. It must have adequate abrasion resistance against loosely packed powder pellets. The Ordnance Dept. has determined that a phenol formaldehyde resin composition best meets these specifications.

During actual firing, temperatures up to 600 deg. F. are encountered, which cause many organic films to soften and become gummy, thus making the case in the gun breech stick, the most common failure. Other failures are due to blistering, cratering or orange peel, brittleness or inadequate tolerance to oven temperature fluctuations.

To evaluate films for any tendency towards thermoplasticity, the following test was developed: One 4 x 6 in. panel and one 1 x 2½ in. panel are placed in an oven at 600 deg. F., film to film, the smaller panel uppermost, both resting on a steel plate previously brought to 600 deg. F. A 2-kilogram weight, also at 600 deg. F., is placed on these panels. After 15 min. the weight is removed, the panels held in reverse position (the larger now uppermost) when the smaller panel should fall away from the larger freely, thus proving the absence of thermoplastic tendencies.

Under-baking the film must be avoided. The test usually employed consisted of immersing the film in acetone and immediately rubbing with the fingernail. Softening of the film indicates insufficient cure. However, this has been superseded by the abrasion resistance test, based on the number of litres of sand needed to wear through the film to a spot having a diameter of 4 mm.

Certain set rules on baking have been developed from many observations: (1) Abrasion resistance at a constant film thickness ultimately becomes invariable, once sufficiently high temperatures of curing are used. (2) In baking at 350 deg. F. after 30 min. (at which point complete cure is effected), the abrasion resistance approaches constancy.

To avoid runs, sags and heavy edges in dipping of cases in varnish, the Harper J. Ransberg (Indianapolis) process has been effective. After removal from the varnish vats by automatic means, the cases move along a conveyor at room temperature while the excess material drains. They then enter a high voltage electric field in which the heavy edges or "tears" are repelled from the case in the form of a fine mist in about 4 min. The electrical field is produced by applying the necessary voltage to electrodes that are insulated from the ground, and the finished pieces are grounded through the conveyor. Current consumption is about 500 watts.

## Air-Conditioned Spectrography

*by L. W. Clifford,*
*Westinghouse Electric & Mfg. Co.*

Air-conditioning is being applied to modern spectrographic analysis rooms since specks of dust and wrong degree of humidity interfere with accurate work. Briefly, to review the metallurgic spectrograph analysis, small electrodes are first molded from the metal to be analyzed. An electric arc is drawn between these sample electrodes and a light beam from this arc is directed by lenses and prisms and focused on the sensitized film held in a frame in the spectrograph cabinet. From the location and intensity of the many spectrum lines on the developed plate or film, the laboratory technician can read the complete analysis of the metal samples.

The lenses and prisms must be free from dust, lint and marks from perspiring hands. The fine apertures through which the light beam passes also must be free from dust flecks. The relative humidity must be kept constant to assure consistent performance of the arc interrupter device.

The emulsified plates or films must be stored under carefully controlled conditions of temperature and relative humidity to prevent their deterioration and subsequent poor results when they are used. Constant temperatures are important also in maintaining a fixed focus in the optical equipment. Air conditioning helps take care of all these details.

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## Tumbler Replaces Rack for Metallizing

*by C. P. Fisher, Jr.,*
*General Electric Co.*

Small magnet inserts were formerly sprayed with aluminum in a wooden rack. About 1000 inserts a day could be so metallized, and it needed 375 lbs. of aluminum to treat 60,000 pieces.

By a new method, 1000 can be done in 12 min., and it requires only 10 to 12 lbs. of aluminum for the 60,000 pieces. With the new method, which

is faster and better, a tumbler is used, as depicted in the accompanying photograph.

# Metallurgical Engineering Digest




## 1 Metal Production

*Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric Furnace Melting Practice, Equipment and Refractories. Melting and Manufacture of Non Ferrous Metals and Alloys. Soaking Pits and Other Steel-Mill and Non-Ferrous Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill, Pickling and Heavy Forging Practice.*

## 2 Foundry Practice

*Melting and Pouring of Gray Iron, Malleable, Steel, Brass and Bronze, Aluminum and Magnesium Castings. Molding, Core-Making, Gating and Risering, etc. Foundry Furnaces, Refractories, Ovens, Molds, Sands, Binders, Auxiliary Equipment and Materials.*

## 3 Metal-Working and Treating

*Die Casting. Powder Metallurgy. Drop, Hammer and Upset Forging. Press-Forming, Drawing, Extruding and Stamping. Machining, Grinding and Polishing. Hardening, Tempering, Age-Hardening, Annealing and Malleableizing. Carburizing, Nitriding and Surface Hardening, Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting. Cleaning, Pickling, Degreasing and Sandblasting. Electroplating, Anodizing, Galvanizing, Metal-Spraying, Coloring, Buffing and Organic Finishing.*

## 4 Materials and Engineering Design

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## 5 Testing, Inspection and Control

*Specifications. Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. Radiography and Magnetic Inspection, Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Inspection and Technique.*

# Metal Production

*Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining • Open-Hearth, Bessemer, Electric Furnace Melting Practice, Equipment and Refractories • Melting and Manufacture of Non Ferrous Metals and Alloys • Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces • Steel and Non-Ferrous Rolling, Wire Mill, Pickling and Heavy Forging Practice*

CONTENTS



## Sinter for the Blast Furnace

*Condensed from "Blast Furnace and Steel Plant"*

In 1938, the Wisconsin Steel Works, South Chicago, Ill., installed a continuous-type, downdraft, Dwight-Lloyd sintering-machine, operated on the wet basis. At first, stock flue-dust and current flue-dust were sintered together. Later a small percentage of ore was added. This increased the output of the machine and resulted in much smoother operation and other beneficial effects.

General practice then was to use about 20 to 30 per cent ore in the mixture. With more fine ore available in 1942, the amount of ore in the mixture was increased to 60 per cent in July. This resulted in increasing the production of the machine from 700 to over 1000 tons per day. Some credit for this increase must be given to the small amount of open-hearth slag screenings also added.

The sintering plant enables the fine ore to be kept separate from the oversize ore during the ore concentrating process, and the sintering of the fines then permits charging into the furnace a material that compares favorably with the oversize ore in physical and chemical properties. The increase in iron units by using either oversize beneficiated ore or sinter in the furnace burden has much to do with improving the production of the furnace.

Tests on two identical furnaces in which various percentages of sinter were charged showed that increasing sinter beyond 20 per cent of the total burden had little effect on increasing furnace production and caused irregular furnace operation. However, production fell off when no sinter was used in the burden.

Lowering the percentage of fines in the furnace burden, either by adding coarser material as sinter or by screening out the fines and charging the oversize ore, will accomplish somewhat identical results. The author's opinion is that greater improvement in production results from beneficiation of the ores than from charging sinter in the furnace.

This opinion was confirmed by tests in which one furnace was run with 45.4 per cent of oversize beneficated ore in the burden, with no sinter charged. An identical furnace was charged with 44.7 per cent sinter and no oversize ore. The first furnace produced 57 net tons more per day and had a considerably lower coke rate than the second.

—Melvin C. Nickel, *Blast Furnace & Steel Plant*, Vol. 31, April, 1943, [supplement] pages 65, 67-71.

## Making Arc Welding Electrodes

*Condensed from "The Iron Age"*

In making mild steel electrodes, a steel rod is drawn to size, straightened and cut to proper lengths. The diameter is held to ± 0.002 in. The cut lengths are run through the extrusion die block of a hydraulic press. Here the coating is extruded at high pressure onto the bare wire.

They are next taken to a rotating stripper brush which removes a portion of the flux coating from one end of the electrode. The average bare portion of 5/32 in. diameter electrode and smaller is 5/8 in.; above 5/32 in. the diameter is 3/4 in. Special instruments keep close check on the thickness of the coating. If the coating is off-center beyond certain limits, serious trouble may occur.

One of the purposes of the coating is to generate a gaseous shield around the arc. This protects the electrode metal from the oxidizing and nitriding effect of the atmosphere during its transfer across the arc.

The ductility of mild steel plate of good welding quality is about 22 to 25 per cent elongation in 2 in. Bare or lightly coated electrode will deposit weld metal from 6 to 10 per cent elongation.

### Three Electrode Coatings

The three general mild steel electrode coatings are: (1.) Cellulosic, often referred to as high-ignition loss type; this type contains sodium silicate, alpha-cellulose, asbestos, ferromanganese and titanium oxide; (2.) Mineral, containing sodium silicate, ferromanganese, iron oxide, silica or quartz; this type is known as a high slag forming type. Deposits from such electrodes are high quality; and (3.) Rutile, this is also a mineral coating. It contains an abundance of rutile ($TiO_2$), some ferromanganese, feldspar and sodium silicate. This is a general purpose type suitable for operation on straight polarity d.c. or a.c.

The American Welding Society has developed specifications which take all conditions into full account and establish limits on physical values of deposited weld metal, covering high quality, all-position type electrodes. Fundamentals which affect the deposition of weld metal are: Current setting, length of arc, angle of electrode, and speed of travel.

Too high a welding current will introduce excessive porosity into the deposit.

High currents will tend to increase convexity in the vertical position. Low current may cause slag inclusions, convex fillet welds and inadequate penetration.

**Proper Length of Arcs**

Lengths of arc for best results will vary with different types and makes of electrodes. Too long an arc will result in improper shielding and may snap out. Long arcs tend to decrease convexity and increase concavity; also increase undercutting. A short arc reduces heat, causing slag entrapment and tends to develop convex fillet welds.

When making a horizontal fillet weld, the electrode should be held at the proper angle in reference to horizontal or vertical plates and also to the line of travel, if proper deposition of the metal is to be obtained. In normal heat, the electrode should be about 45 deg. from the vertical and horizontal plates. The line of travel should be 0 to 30 deg. off the vertical, leaning in the direction of travel. In case of high heat angle should be about 30 deg. off vertical plate and 60 deg. from horizontal plate.

Speed of travel should be just enough to keep the slag from either running ahead of or crowding the electrode. No specific data can be given for speed of travel since it is subject to plate thickness, size of electrode, welding current used, etc.

Weaving is used when it is necessary to weld joints which are wider than can be filled successfully by straight line travel. Good side wall fusion should be obtained in making butt welds.

Whipping is an oscillation of the electrode in the direction of the line of travel. It is used where it is necessary to preheat the work or burn off the coating.

Deposition efficiencies are usually higher for "all position" types of electrodes having relatively thinner coatings than they are for "flat-position" types having relatively heavy coatings.

—H. O. Westendarp, Jr., *Iron Age*, Vol. 151, April 29, 1943, pp. 39-41; May 6, 1943, pp. 62-66.

## Recovery of Scrap Metals

*Condensed from "Foundry Trade Journal"*

The absence of world statistics on the recovery of scrap makes it impossible to give a comprehensive picture of its full significance. However, it is clear from the data on hand that scrap recovery will be of increasing importance as regards the conservation of metal resources, and that as a major source of raw materials it must be brought into any general scheme affecting them under the Atlantic Charter.

At present iron and steel represent about 93 per cent of the total world tonnage of metal production. It has been estimated that of the total output of iron and steel, 15 to 20 per cent is lost from rusting. The recovery of ferrous scrap in U.S.A. has reached in recent years 75 per cent.

American statistics for 1929-38 show a recovery of metallic tin from scrap amounting to 8 per cent of the total consumption as pure tin and alloy, and a recovery in the alloy form amounting to 26 per cent. Same statistics show that out of a total

production of one million tons of aluminum, 1/5 came from scrap recovery. In addition, about 225,000 tons of aluminum was recovered in the form of various alloys, making the total contribution of scrap to consumption about 35 per cent.

United States domestic consumption of copper for 1929-1938 was approximately 6.5 million tons, of which 2.5 million tons or 39 per cent came from scrap recovery. In the U.S.A., scrap recovery of nickel has progressed steadily, and in 1938 was about 2,000 tons, which is, however, only a small percentage of consumption. Little is known about the recovery of chromium.

—Harold Hartley, *Foundry Trade J.*, Vol. 69, Mar. 25, 1943, pp. 245-248, 250.

## NE 1330 Steel in the Open-Hearth

*Condensed from "Blast Furnace and Steel Plant"*

A 50-ton basic open-hearth furnace is used. Cold charge consists first of 6000 lbs. of heavy melting scrap placed on a "Basifrit" bottom, then 4800 lbs. of limestone and 4000 lbs. lime, 27,000 lbs. of steel scrap, and 22,000 lbs. of cast iron. After melting down in about 3 hrs., 33,000 lbs. of steel scrap and 22,000 lbs. of pig iron are added.

After it has been determined that the heat is completely melted (about 4 more hrs.), 75 lbs. fluorspar are added through each of the furnace's 3 doors. This produces a fluid slag in about 20 min. Then viscosimeter, slag, and carbometer tests, and laboratory determinations of sulphur and phosphorus are made. These require about 30 min., during which the furnace temperature is maintained at a maximum, using oil with 80 lbs. steam pressure.

Viscosimeter reading should be 5 in.; total $Fe_2O_3$ in slag, 12 per cent; S in bath, 0.040; P in bath, 0.020; and C, 0.40 per cent. At the end of the 30 min., carbometer test should show 0.25 per cent C, viscosimeter should remain at 5 in.; and $Fe_2O_3$ in slag should be 15 per cent.

Then 1000 lbs. spiegel containing 4 C, 19 to 21 Mn, and 1 to 2 per cent Si are added, requiring 30 min. at maximum furnace temperature to melt. Another test should show 0.25 per cent C. To obtain the ideal of 0.18 per cent C at this point, maximum furnace temperature must be maintained another 30 min., during which stirring rods are constantly used in the bath.

Assuming that at this time, viscosimeter reading is 7 in., total $Fe_2O_3$, 17 per cent, and laboratory determinations will show 0.18 C and 0.30 per cent Mn, 1000 lbs. silicomanganese are added to the bath. Oil under 80 lbs. steam pressure is allowed to remain on the furnace for 5 min., then it is shut off for 10 min., and turned on again with 40 lbs. steam pressure, while waiting for laboratory report.

If the laboratory reports are satisfactory, a steel test for determination of manganese and viscosimeter and slag tests are taken, 2000 lbs. of 80 per cent ferromanganese (6% C) are added to heat, and steam pressure is immediately increased to 60 lbs. These final tests require about 15 min., generally sufficient to melt the manganese completely.

If the heat has proceeded true to form,

the viscosimeter reading should be 3 in., total $Fe_2O_3$ in slag, 14 per cent and manganese in the steel, 0.72 per cent. Under these conditions final addition is 100 lbs. of 80 per cent ferromanganese. As soon as this is made, the tap-hole should be opened. At this time, viscosimeter reading should be 10 in., and total $Fe_2O_3$, 17 per cent.

As the molten metal begins to flow down the runner, 600 lbs. of 8-mesh 50 per cent ferrosilicon, 50 lb. virgin aluminum, and 100 lbs. ferrocarbontitanium are added to the ladle. The heat is completely tapped within 6 min. from opening the tap-hole. The temperature of the molten metal is about 2940 deg. F. The heat should be held in the ladle for 8 min. before pouring. Final composition should be 0.31 C, 0.022 S, 0.019 P, 1.77 Mn, and 0.28 Si. The elapsed time is about 9½ hrs.

Difficulties which had to be overcome in the development of the above practice were, in the order of their importance, "phosphorus kick-backs," "silicomanganese recovery," "unmelted manganese," "high melts," "low melts," and "bottom boils."

Originally 15 per cent Si pig iron was used. Then, it was necessary to kill the heat at 0.14 per cent C, by adding 2950 lbs. ferromanganese. The low carbon content and excessive amount of ferromanganese required resulted in missing more than half the heats. By substituting silicomanganese and helping the open-hearth men to overcome the difficulties encountered, efficiency in meeting manganese specification increased to 98.4 per cent in 1942.

—Ernest G. Wigfield, *Blast Furnace & Steel Plant*, Vol. 31, May, 1943, pp. 513-515, 520-521.

## Carbon—a Refractory Material

*Condensed from "Steel"*

Carbon does not melt at any temperature but volatilizes at 6634 deg. F. Mean coefficient of expansion of carbon and artificial graphite blocks is 0.00000188 and 0.00000153 respectively for the normal refractory range up to 3000 deg. F. At 2000 deg. C. (3630 deg. F.), strength under compression is about the same as at room temperature. Carbon is highly resistant to chemical attack.

The greatest use of carbon as a refractory is in the electrolytic cells for production of aluminum. The carbon pot lining completes the electrical circuit at the cell cathodes and withstands the chemical attack under fairly severe temperature conditions as well as mechanical abuse.

Lining may be made of carbon blocks formed, baked to 1000 deg. C. (1830 deg. F.), and machined to fit the heavily reinforced iron pot with its installed current conductors, or it may be carbon paste tamped into the pot and around the current conductors while hot and plastic and then baked into a monolithic lining by the heat developed in the cell by the electrolytic process. The mass consists of calcined anthracite coal particles and calcined petroleum coke flour mixed with tar or pitch to make a homogeneous mass.

One cell may require up to 25,000 lbs. of carbon lining which will have to be com-


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pletely replaced within 1 to 2 yrs. For every 100 lbs. of aluminum produced, 50 to 75 lbs. of electrodes and about 7½ lbs. of carbon lining are needed.

Hearth blocks run crosswise of the furnace in two sections from the shell inwards meeting at the center in a row of staggered joints. The joints between blocks are about 2 in. wide and are filled with carbon paste, which is heated in small quantities to 100 to 140 deg. C. (212 to 284 deg. F.) and rammed in. Monolithic linings are cheaper than prebaked ones, but have several disadvantages.

Second in amount of carbon used for refractory purposes are the various types of ferroalloy furnaces, some calcium carbide furnaces, and all furnaces producing phosphorus, ferrophosphorus, and phosphoric acid electrically. Virtually all ferroalloy furnaces are lined with preformed blocks shaped to conform to furnace dimensions. Using wide joints as in aluminum pots is cheaper than having all surfaces machined so that all joints are virtually carbon block to carbon block.

Blocks of standard sizes should be used. A double layer of blocks with staggered joints is better than a single layer. The life of a carbon lining is affected by many things. Proper design is an important factor, as is prevention of air infiltration. Proper operation of the furnace is perhaps the most important of all. Probably a life of 2 to 5 yrs. is average.

Graphite machines more easily than carbon. Parts requiring involved or complicated machining should be made of the former unless its high heat conductivity and greater electrical conductivity preclude its use. Graphite can be worked easily on any metal-working equipment.

In Europe, carbon has proved a superior lining material for blast furnace hearth and tuyere sections and up to the mantle. Much experimental work has been done on use of carbon in electric steel furnaces. The principal disadvantage is that carbon oxidizes at a relatively low temperature and the atmosphere in an electric steel furnace is almost always oxidizing.

The steel industry is using carbon mold plugs, carbon bricks in blast furnace runout troughs, carbon bricks for lining tanks in which stainless steel is pickled, and graphite molds for casting machine-tool and special metal bits for oil-well drilling. Graphite molds and stools are used also in casting non-ferrous ingots. Carbon and graphite have numerous applications in the chemical field.

—Frank J. Vosburgh, *Steel*, Vol. 112, April 5, 1943, pp. 106-108, 110-145; April 12, 1943, pp. 118, 120, 125, 146-147.

## Australia's Ferro-Alloys

*Condensed from "Foundry Trade Journal"*

Australian resources are listed as follows: *Silicon*—Ample supplies of quartzite are available in many places throughout Australia. *Manganese*—Several deposits of medium grade manganese ore are known. *Chromium*—Several small low-grade deposits are known, but these are more suitable for making refractory chrome bricks than for ferrochrome. There is the possibility of a good deposit being worked in Western Australia.

*Tungsten*—Ample supplies are available locally; scheelite ($CaWO_4$) is mined at King Island in Bass Strait, while wolframite ($FeMnWO_4$) comes from Tasmania. *Molybdenum*—The known deposits of molybdenite ($MoS_2$), the chief ore of Mo are very limited in Australia. The local deposits are being developed.

*Zirconium* and *Titanium*—Ample supplies are available from extensive black sand deposits occurring on the North Coast of New South Wales. *Nickel*—Deposits of ore occur in New Caledonia and could no doubt be smelted in Australia if necessary. *Copper*—Local deposits are adequate, and production is chiefly from Mt. Lyell in Tasmania. *Aluminum*—Low-grade deposits of bauxite are known in Australia, and local production of aluminum is contemplated.

There are three principal methods of manufacture of ferro-alloys: (1) Blast furnace, used only for high-carbon ferromanganese and ferro-phosphorus; (2) electric arc furnace, which can be used for all ferro-alloys and (3) thermit crucible, in which process the ferro-alloy is produced in a small cone-shaped crucible by reduction of the ore with aluminum. All these methods are discussed at length.

—W. Hewitt, *Foundry Trade J.*, Vol. 69, Feb. 11, 1943, pp. 119-122.

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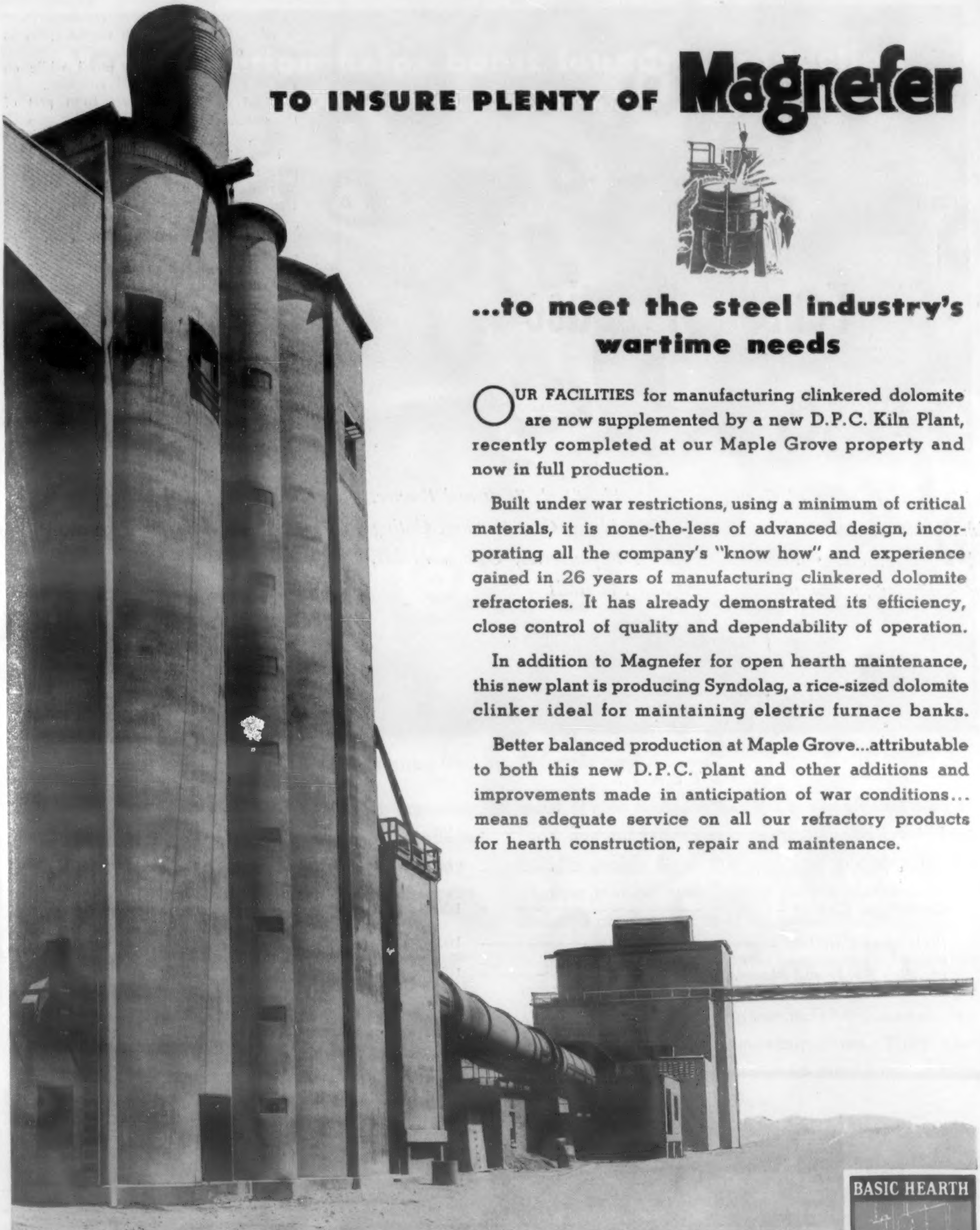

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CONTENTS



## Piston Ring Castings

*Condensed from "The Foundry"*

The article describes procedure at the plant of Perfect Circle Co. making piston ring castings in sizes from 1 to 9 in. in diameter. Sand is tested at regular intervals to maintain uniform quality essential to the production of the delicate castings. Standards include moisture 4 to 4.5 per cent, grain size 150, green strength 6, dry strength 29, clay content 9 per cent, permeability 20, flowability 85, and deformation 0.012.

Batteries of molding machines are set up in a straight line and are of the squeezer type. Special features include a pneumatic device for moving squeezer head to the on or off position, pattern heating unit and an air-operated arrangement for moving stripping pins and sprue up and down.

Cast iron patterns are mounted in groups of 2, 4, 6 or 8. Flask used is a large square one of 1¼ in. depth and a smaller round one of 1⅛ in. depth. Very hot metal is required to pour the castings. It is taken direct from the cupola spout in 200-lb. capacity ladles.

Molds are filled with metal while on the first leg of the oval conveyor. Individual casting containers form part of the system for recording the work of each molder.

Even at present, with all the problems practically eliminated, the yield of castings in proportion to the metal poured is as 1 to 3. The remainder become sprue, gate and runner.

To eliminate sensitivity to change in temperature near the gate, a miniature blind riser, known as a pollywog is attached to the casting at this point. When the cold head of the stream flows into the pollywog, the temperature of the metal in the entire ring is practically uniform.

Metal is melted in a battery of 5 cupolas. The 30-in. cupolas contain 400 lbs. of iron, 70 lbs. of coke, and 25 lbs. of dolomite screened to about 1 in. size. For the 42 in. cupolas charges are 1000 lbs. of iron, 175 lbs. of coke and 60 lbs. of dolomite. Slag runs through a spout at the back and falls into a conical shaped pot.

—Pat Dwyer, *Foundry*, Vol. 71, Mar. 1943, pp. 88-91, 179.

## Silicon Carbide Refractories

*Condensed from "Die Giesserei"*

Silicon carbide has assumed increasing importance in Germany among the various types of heat-resisting materials. It is now used as a substitute for sillimanite, which is not available to German industry during the war.

Until shortly before the war, bricks with small silicon carbide content were tried, but were found to be considerably weaker than those of higher percentage. Two types are manufactured at present. The properties of the medium silicon carbide type approach those of special products of high clay content, while the 85 per cent SiC materials show a compressive strength of 1000 kg. per sq. cm. and very low coefficient of linear expansion.

Silicon carbide has a higher thermal conductivity than other refractory materials. The brick may be decomposed in the presence of oxygen to form silica and carbon dioxide, unless protected. Glazing the surface of the brick, and selection of raw materials to reduce the grain size suitably, as well as suitable construction methods, are used to prevent oxidation.

### Service Factors

The bricks offer great resistance to disintegration by liquid slags. After proving their superiority in connection with coal slags, they were used in coke-fired furnaces to melt nickel. Their success here led to their use for tool steel production, and here again they were superior to the high clay bricks previously used.

As the silicon carbide is comparatively expensive, only the barest minimum was used. Use of high grade heat resisting bricks at the height of the grate, where wear is least, helps to eliminate oxidation. Silicon carbide bricks follow, and at the top is another layer of heat resisting bricks. Heat distribution in the wall must be carefully checked to ensure that

temperature is not raised excessively because of the high conductivity of the silicon carbide, thus damaging the other bricks. A suitable mortar is required.

In aluminum melting furnaces silicon carbide is used to protect the electrical heating element from aluminum spray. It is often used for baffle plates in the enamel plants frequently attached to foundries. The thermal conductivity is utilized in this latter case to obtain the unequal heat required; for example, using high grade silicon carbide bricks for the roof and ordinary heat resisting bricks for the floor gives overhead temperature.

The use of silicon carbide for crucibles, *e.g.*, for aluminum casting, has been suggested, owing to its high tensile and bending strength. However, only the glazed brick could be used. The material already replaces graphite in zinc melting plants.

—Chr. Bruchhausen, *Die Giesserei*, Vol. 29, No. 12, 1942. (Translated in *Engineer's Digest*, Vol. 4, Feb. 1943, pp. 55-57.)

## Centrifugal Casting

*Condensed from an American Foundrymen's Association Paper*

The Allis-Chalmers Mfg. Co., in experimenting to reduce costs by a centrifugal casting process for non-ferrous metals, also produced a better article. The casting is without a center core, the centrifugal force of the rotating mold holding the molten metal against the outer walls and leaving a relatively straight open hole through the center. After the machine is started a measured quantity of molten metal is poured into the mold. When the metal is set, the machine is stopped, the cover removed, and the casting withdrawn with expanding tongs.

### Speed of Rotation

The centrifugal force varies directly as the diameter and as the square of the speed. The taper in the hole is the result of the combined centrifugal force and gravity pull, and depends only on the diameter of the bore and the speed of rotation. Experiments proved that a speed which gave a taper of 1:100 was best.. This means that the centrifugal force on the inside of the casting must be 100 times greater than the gravity weight and can be called 100 G's. . A curve has been plotted which may be used by taking the diameter of the cast hole and looking up its corresponding speed on the curve. It is used only for thin-walled castings because the G value increases toward the outside of the casting and with extremely thick walls may become dangerously high. In that case, unless the casting machine has been specifically designed for excessive forces, a lower speed must be used, even if it results in more taper of the bore.

As the forces on the outside of the flask are terrific and increase directly as the size, the design must be strong enough to withstand them and guards should protect the workman from possible failure. They also protect him from flying metal.

### Angle of Shaft and Pouring Spouts

The metal must be poured as rapidly as


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possible against the center of the bottom of the mold. When the metal arrives at the same speed of rotation as the mold, it rises carrying the dirt and dross to the upper part of the bore and up against the cover. As the angle of the shaft is decreased the dirt and dross spread down the bore. The best operating angle will be reached when the bore shows an even distribution of impurities over its entire length.

In a long casting, four times the finished bore size in length, a bent spout must be used, to enable the metal to strike the center of the mold. The discharge ends of all spouts must be perfectly smooth as a small lip or obstruction will deflect the metal and cause a poor outside finish.

#### Mold Material

To date, graphite, purchased in the form of electrodes for electric furnaces, is the most satisfactory material for molds. For orders of 200 or more identical parts, good results were obtained with cast iron molds as the length of life of the mold balances the higher initial cost. Graphite molds are the only ones that can be used with such metals as 80-10-10 containing high amounts of phosphorus, as these alloys do not fuse with the graphite. Also the metal lies quieter against the graphite and, as the graphite has a low coefficient of expansion, the size of the casting does not vary much with changes of temperature and the shape does not distort with repeated heat shocks.

For semi-permanent molds, to make a few pieces, fire clay has been used for as many as four castings with no bad effects. Baked core sand molds are ideal because of their insulating properties, but the difficulty of removing the castings, the increase in casting time, and the cleaning of the castings, result in increase in cost.

#### Measuring and Pouring Metal

In measuring the metal for small castings, volumetric measurements are the easiest. Laboratory crucibles from No. 0 up are used and must be kept hot. In a heat of 2 or 3 castings, the metal is weighed. When the metal is entering the mold the temperature may be somewhat less than in conventional casting. But as there is a loss of about 50 deg. F. in each step of the pouring, the furnace temperature must be 100 to 150 deg. F. hotter than in sand castings. For aluminum bronze, 2100 to 2200 deg. F. is used and for tin bronzes not over 2100 deg. F. Oxide in the bore shows excessive temperatures have been reached.

In making larger and longer castings, ¼ to ⅓ of the pour is made with the machine at rest so that the first rush will cover the walls. A flatter angle is used which also facilitates removal.

#### Advantages

Centriifugal casting gives clean metal because, if the temperature and speed of rotation are correct, the impurities are forced to the inner surface where they can be removed by machining. Up to the limit of progressive solidification, the density of these castings is 0.5 per cent greater than that of a similar static casting. When this limit is reached, due to the thickness of a casting, the spongy condition resulting can be improved by slower pouring and throwing powdered charcoal into the mold..

The grain is finer than in sand casting and with non-ferrous castings the tensile strength is higher. In iron castings it may be slightly slower. When permanent molds are used cost of production by the centrifugal process is lower than that of the conventional process.

—Harold B. Zuehlke, *American Foundrymen's Assoc., Preprint No. 43-2,* April, 1943.

## Fluidity of Cast Iron

*Condensed from "Foundry Trade Journal"*

To measure fluidity a form of the spiral test was used by the author. His spirals were run at the center of the spiral and had no risers.

The fluidity test described is used in connection with the casting of individually-cast piston rings, these castings requiring a high degree of fluidity in the iron used. This is a soft iron of the following approximate composition: T.C 3.5 to 3.9; Si, 2.5 to 2.7; Mn, 0.6 to 0.7; S, 0.06; and P, 0.5 to 0.6 per cent.

The fluidity of this metal is remarkably sensitive to changes in composition, the temperature of the metal being kept high and as constant as possible through the

day's run on the cupola. For example, two fluidity spirals were cast at the same temperature. One was found to be much longer than the other, spiral No. 1 being 91 cm. long and spiral No. 2, 33 cm. long. The difference in fluidity was accounted for by the difference in chemical analysis, as follows: Spiral No. 1: T.C, 3.81;Si, 2.40; Mn, 0.68; S, 0.059; P, 0.56 per cent. Spiral No. 2: T.C, 3.92; Si, 2.55; Mn, 0.65; S, 0.062; P, 0.56 per cent.

The spiral test mold was cast in exactly the same way as the actual ring mold. The spiral casting is then knocked out and its length measured off directly by means of notches in the casting at 5 cm. intervals. This is done by placing it on a brass plate, graduated off up to 140 cm.

#### Effects of Composition

It is likely that the fluidity would reach a maximum at the eutectic carbon composition. Unfortunately in practice this figure is never reached, since the casting is small and a chilled casting would result.

Eutectic carbon composition is obtained by adding silicon and phosphorus percentages of a given iron, multiplying this figure by 0.3 and subtracting the result from 4.3, which is the eutectic carbon content for pure iron-carbon alloy. Thus, for high-silicon, high-phosphorus irons (total percentage 3.0) maximum fluidity would be attained with fairly low total carbon, *e.g.*, 3.4 per cent C.

Conversely, low-carbon irons would be more fluid with high silicon and phosphorus. Low-phosphorus hematite irons in which total silicon and phosphorus would be about 1.5 per cent would have maximum fluidity with about 3.85 per cent C. Two charges cast into the same size of casting under the same conditions were found to be identical in analysis, except graphitic carbon. The one low in graphitic carbon had normal fluidity, while the high graphitic carbon had low fluidity. The relatively small percentage of sulphur usually found in cast iron will not greatly affect the resultant fluidity of the cast iron, but, it has been said that sulphur decreases fluidity.

In the case of manganese, it was noticed that this element seemed to cause short-run risers, in the small individually cast piston rings. For this reason it was never allowed to exceed 0.7 per cent. [*Since the temperatures were measured by means of the optical pyrometer it is rather doubtful that the graphs shown in the paper represent a true "length of spiral-temperature" relation for the irons investigated.*—A.I.K.]

—G. Burgess, *Foundry Trade J.*, Vol. 69, Mar. 11, 1943, pp. 197-203.

## Molding Sands and Materials

*Condensed from "Foundry Trade Journal"*

Limited, selected and treated varieties of Fuller's earth, occurring in England (Somerset and Surrey) to which the general designation Fulbond has been given, and which have bonding characteristics close to those of normal bentonites, have been developed. Investigation into the use of core binders was made with particular reference to the possibility of effecting a reduction in the consumption of linseed oil and corn starch products.

In many cases up to one-half of the linseed oil in a core mixture can be replaced by binders like Truline (a synthetic resinous material) without detriment to the strength and collapsibility of the core. Truline binder is particularly effective where reclaimed sands are used for core-making.

Special attention is directed to the desirability of the calibration of pressure gauges on hydraulic machines for the measurement of dry strength. In other work on the testing of sands a new simple type of permeability apparatus has been developed, which gives accurate results for sands of both high and low permeability. An investigation on the hot strength of molding sands is in progress, and it seems likely that its results will provide data of definite value to foundries, especially when considered in conjunction with high-temperature sintering tests.

#### Permeability Tests

The British Cast Iron Research Association air permeability apparatus seems to have several disadvantages. The chief of these is that the pressure in the air reservoir is not constant; it depends on the permeability of the test-piece. Further-

more, the rate of sinking of the reservoir depends not only on the permeability of the test-piece, but on the resistance due to the viscosity of the water in the reservoir and to the friction between the sliding tubes in it.

The importance of the pipeline and reservoir resistance increases as the permeability of the test-pieces is increased. To overcome this difficulty, a modified form of permeability apparatus was designed. In this form, the reservoir floats on water and is maintained in an upright position by means of a small counterpoise.

The outlet from the reservoir is made of steel pipe, having a bore of 2 in. and a length of more than six diameters; a disc of wire gauze is fitted in the pipe at a distance of two diameters from the top. By this means the air flow is rendered uniform over the whole of the cross-section near the bottom of the pipe, that is, at the point where the pressure is measured. The test-piece is rammed in a short length of pipe of 2 in. bore and attached to the outlet pipe by means of a union; the joint is made air-tight by a rubber washer.

In operation, the lower end of the test-piece holder is closed by a glass plate coated with vaseline. The vent tap is opened, the reservoir raised and the tap closed. The level of the reservoir is then observed to see that there are no leaks.



If there are none, the glass plate is slipped off, and the time for the passage of 1 litre of air and the manometer readings are noted. The pressure when the glass plate is in position is 7.35 cm.; this falls to 7.2 cm. when the plate is removed, and this value is independent of the permeability of the test-piece.

If the empty test-piece holder is used, the reservoir discharges instantaneously on the removal of the glass plate. Thus, the resistance due to the pipeline, friction and viscosity are negligible.

The permeability number P, according to Wologdine (*Stahl und Eisen*, 1909, Vol. 29, p. 1221), is given by the expression $P = v \times h/p \times a \times t$ where v is volume of air passed, in ml.; h is height of specimen, in cm.; p is pressure during experiment, in cm of water; a is cross-sectional area of test piece, in sq. cm; t is time, in min. If v and a are constant, the factor PT/H should be a constant. This is true of the modified apparatus but not of the B.C.I.R.A. apparatus.

### Core Binders

Various materials used as core binders are grouped as follows: (1) Solid substances, or nearly solid, at ordinary temperatures. They soften or melt on heating, forming a film round each sand grain. The best known example is probably common resin or colophony.

(2) Substances which on heating undergo a chemico-physical change, with evaporation of water, and leave a solid residue. The commonest example is molasses and sulphite lye.

(3) Substances which are dissolved in a volatile solvent. For example, rubber latex may be dissolved in a solution of ammonia in water. The rubber may also be dissolved in a volatile organic solvent such as trichlorethylene. Cellulose derivatives such as acetates and hydrates may be dissolved in organic solvents which evaporate on heating.

(4) Oils, which absorb oxygen on heating, leaving a solid residue of considerable strength and some elasticity. (5) Colloids that swell with water and leave a hard residue on heating. The common example is an ordinary glue. (6) Binders of the sodium silicate type. Of course cores can be made in sand mixtures containing clay as the bonding material without any organic binder at all.

The green and dry strengths are not the only properties of core compounds that are important. It is desirable that the sand on the core bench should not dry off rapidly. Other factors are ease of working, flowability, resistance to water or water vapor, the nature of the core surface, the nature of the residue left after burning off and nature of the gases evolved during drying and during casting.

The amount of gas cooled on heating a core is of practical importance in the foundry. Apparatus for determining the amount of gas evolved from core sands is described. Means of reducing the consumption of core compounds, experiments on economy mixtures, use of industrial waste, etc. are also discussed.

—*Foundry Trade J.*, Vol. 69, Jan. 21, 1943, pp. 47-54; Mar. 4, pp. 175-179; Mar. 18, pp. 186, 227; Apr. 15, pp. 307-310; Apr. 29, pp. 349-351.

# Metal-Working and Treating

*Die Casting • Powder Metallurgy • Drop, Hammer and Upset Forging • Press-Forming, Drawing, Extruding and Stamping • Machining, Grinding and Polishing • Hardening, Tempering, Age-Hardening, Annealing and Malleableizing • Carburizing, Nitriding and Surface Hardening, Heating Furnaces, Refractories, Fuels and Auxiliaries • Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting • Cleaning, Pickling, Degreasing and Sandblasting • Electroplating, Anodizing, Galvanizing, Metal-Spraying, Coloring, Buffing and Organic Finishing*

*CONTENTS*



## Solders That Save Tin

*Condensed from "Canadian Metals and Met. Industries"*

Every soldering operation involves 4 main considerations: (1) kind of metals to be soldered; (2) how the soldering is accomplished; (3) the composition of the solder; and (4) the flux composition. The finished joint must possess: (a) tensile strength, (b) shear strength, (c) capillary rise of solder in joint, and (d) corrosion resistance.

The strength of a soldered joint is directly dependent on the thickness of the solder employed. Old types of fluxes are quite ineffective with silver-lead solders. "Tinning" was formerly used to provide the necessary wetting action, but wartime restrictions have led to the production of tinning alloys containing only 10 per cent Sn, which have given satisfactory results for over a year.

A 2/98 tin-lead alloy for coating sheets, fabricated articles or copper acts as a lubricant on sheets when drawn, is more ductile than common coatings, can readily be soldered with non-acid flux, can be painted immediately and is more economical than the usual zinc, because 60 lbs. of tin-lead alloy will do the work of 100 lbs. of zinc.

**Preparation of Material**

The steel, copper, or brass sheets or other shapes are thoroughly cleaned with trisodiumphosphate solutions or vapor degreasers for oil, grease or drawing compound, and shot or sand blasted for scale or oxidation. A phosphate-cleaned article is rinsed in plain water, dipped in 5 per cent muriatic acid solution for pickling, while a shot or sand blasted article may be pickled, if necessary

After pickling, while still wet, the article is placed in the anhydrous flux bath at 650 deg. F. and kept there until it reaches the temperature of the flux. The article is removed from the flux and dipped into the 2/98 Sn-Pb alloy bath. Submersion is long enough to insure thorough heating, after which the article is withdrawn through a clean metal surface free from flux. The article is then quenched in paraffin oil at a temperature of about 300 deg. F. or in clear water.

For general hand soldering alloys containing 20 per cent Sn, with partial tin replacement by bismuth, offer advantages over the silver-lead alloys in the following respects: they have (1) low melting point, (2) increased fluidity, and (3) increased wetting power, and (4) they are readily handled with hand iron. The majority of soldering jobs may be classified into two groups: those that can tolerate a relatively high temperature without any detrimental effect on the finished product; and those jobs where there is danger of undesirable results with higher temperatures. A third group is made up of the soldering of milk and cream cans and general dairy equipment.

For the first group, silver-lead is recommended. For general hand soldering a cadmium-lead alloy is the best alternate to 50/50 Sn-Pb solder, and for soldering of milk and cream cans a tin-lead-silver alloy is recommended.

—Geo. F. Beard, *Can. Metals & Met. Inds.*, Vol. 6, Mar. 1943, pp. 20-23.

## Black Nickel Finishes

*Condensed from "Metal Finishing"*

Many articles for military use require a dark-colored, non-reflective finish. Black nickel is one of the most satisfactory of the different black finishes which can be produced on metal surfaces.

Black nickel may be deposited on almost any base metal. If a corrosion resistant coating on steel is desired, the black nickel should be deposited on a zinc undercoat, since the black nickel itself confers very little corrosion resistance. If an abrasion resistant finish on a soft metal is desired, a hard undercoat, such as nickel, should first be deposited. A buffed base metal will produce a reflective black nickel, while a mat base metal finish will produce a dead black nickel. Base metals must be thoroughly clean, and free of "water-break" prior to deposition of black nickel.

A recommended plating solution for still plating contains double nickel salts, 8 oz./gal.; ammonium thiocyanate, 2 oz./gal.; zinc sulfate, 1 oz./gal. A solution for barrel plating contains double nickel salts, 8.5 oz./gal.; potassium thiocyanate, 1 oz./gal.; benzoic acid, 1.5 oz./gal. Addition of 1.5 oz./gal. of nickel carbonate helps to regulate the acidity of

the bath. The solutions are operated at room temperature and with an applied potential of 0.5 to 1.0 volt. When the proper current density (or voltage) is used, no deposit is visible for a few seconds. The color then varies through yellow, blue, iridescent, and finally black. If the article becomes black immediately the current density is too high and the deposit may peel. Nickel anodes are used, and the anode area should be as large as possible.

The solution should be operated in the pH range of 6.0 to 6.4 (colorimetric). The acidity tends to increase during operation, resulting in gray and streaked deposits. Ammonia, nickel carbonate, or zinc carbonate, may be added to control the acidity.

The black may develop a brown shade on standing. A black color may be restored to a gray or brown deposit by dipping for 15 to 20 sec. in a cold solution containing 12 oz./gal. of ferric chloride and 1 oz./gal. of hydrochloric acid. Faster results are obtained if the dip is warmed to 120 deg. F., but it should not be used above this temperature.

Black nickel deposits should be lacquered for best results. This prevents the development of an iridescent color on aging of the deposit. A heavy lacquer should be used, since a thin one results in an iridescent effect.

The causes and remedies of various difficulties which may be encountered in operating black nickel solutions are discussed.

—E. Schore, *Metal Finishing*, Vol. 41, 1943, pp. 77-79.

## Aircraft Sheet-Metal Forming

*Condensed from "S.A.E. Journal"*

This article deals particularly with sheet-metal forming for the production of aircraft. The most common and widely used sheet-metals are 3S, 24S, 52S, 53S and 61S aluminum alloys.

Basic forming operations in aircraft production are bending, stretching, shrinking, and drawing. Actual parts may be classified as (1) those with straight flanges; (2) those with curved flanges; (3) drawn parts, as cups and boxes; and (4) smoothly contoured parts, as "fairings" and skin surfaces. The first class is nearly always formed by bending. The second class involves shrinking or stretching as well as bending. The fourth class can sometimes be drawn in multiple-action presses, but many such parts can best be formed by stretching or by a combination of stretching and drawing.

**Processes of Forming**

Forming may be done by hand with a hammer; power driven planishing-hammer; crown rolling; drop-hammer; power brake; power driven rolls; punch press; large single-acting hydraulic press using a confined rubber punch in the upper platen; large double-acting press; and "stretching machine." The most important of these are the hydraulic press with rubber platen and the double-acting press.

Rubber pressure forming with the hydraulic press provides a method of obtaining simple flanged parts where a very large number of different parts and a relatively small number of each are required. Tooling is comparatively inexpensive. Consist-

ency of results is affected by average pressure on the platen at which the press is operated, the proximity of adjacent objects on the table, rubber hardness, and form-block height. Angular tolerances of $\pm 2$ deg. should be permitted for straight flanged parts.

Concave flanges may be formed from 24S-O and 24S-T when the maximum tensile strains do not exceed 10 to 12 per cent. This may be considerably exceeded in some special cases. Convex flanges may be formed on simple form blocks from 24S-O, 52S-O, 53S-W and 61S-W with compressive strains of 1 to 6 per cent depending on material thickness and flange width. Compressive strains greater than 0.5 per cent are difficult to obtain in 24S-T. Effective limits for concave flanges may be increased by using push-through dies, a form of draw die, cut-outs, and "dished" form blocks.

Joggles can be formed in 24S-T by using "dished" form blocks or mechanical rollers. Very narrow flanges may be formed by using mechanical rollers. Forming indentations into the web of a part may often be facilitated by using a pressure pad. Overall forming operations may be improved and spring-back angles stabilized by adjusting operating conditions to obtain the maximum possible pressure on the form block.

The pressure may be increased on particular parts by increasing the applied press load, using displacement blocks adjacent to parts required, and increasing the height of the form block. Use of an excessive number of displacement blocks or high form blocks on any one loading table will not give the desired results.

### Stretch Forming

Stretch forming is limited to parts which do not have severe double curvature. Forming limits of skins and "fairings" are determined by the tensile strains which the material will withstand or by wrinkling of the sheet. Both are determined by the geometry of the part. Considerable difference in maximum obtainable elongation may be gotten for materials with different edge conditions when the maximum strain occurs at the edge of the sheet. Generally, however, edge condition has little effect as the maximum strains usually occur in the middle of the sheet. Elongation in a 2-in. gage length obtained from standard tensile coupons is not indicative of the average elongation obtainable in stretch forming.

A double-acting press is desirable for stretch forming large skins and "fairings" because the high clamping forces available permit the use of flat clamping plates rather than serrated jaws. The latter tend to cause stress concentrations within the clamps, which often result in tearing the sheet during forming. While flat rails consisting of straight-line elements at the inner edges are generally the most practical, it is sometimes advantageous to use curved rails.

The radius on the edge of the rails and punch should be at least 1 in., and larger if possible. The punch should be highly polished and lubricated to equalize strain distribution along the length of the sheet.

Curved channel sections may be readily formed by stretching, thereby eliminating tooling problems due to spring-back in ma-

terials of harder temper. A small stretching machine is usually sufficient for these parts.

Drawing involves a combined stress and strain condition consisting of elongation of the sheet in the radial direction from the part and compression circumferentially. The area of the formed part is essentially equal to that of the unformed blank from which it was produced. Ratio $h/r$ is an index of the severity of forming performed, $h$ being depth and $r$, radius of the formed part.

#### Some Failures

Failures encountered during forming tests were pushing out of the bottom of the part by the punch, failure of the part at a point tangent to the draw radius, and splitting of the side wall of the part.

Within reasonable limits, no scale effect was detected for 24S-O Alclad. Cylindrical cupping tests serve as a conservative index of the drawing limits for materials, but do not necessarily indicate the maximum $h/r$ values to which they may be deformed in shapes which involve drawing of only a portion of the total area. Limits for drawn boxes are influenced by such factors as corner radii, width of flat sides, blank shape, and grain direction of blank.

Parts which are given little support against puckering due to the punch contour, such as hemispherical or dome-shaped bottoms, are limited by the tendency to buckle as well as by the magnitude of the strains required. Puckering may be controlled by varying blank thickness or by increasing blank size or the friction forces acting on that portion of the blank which is in position between the die and pressure pad.

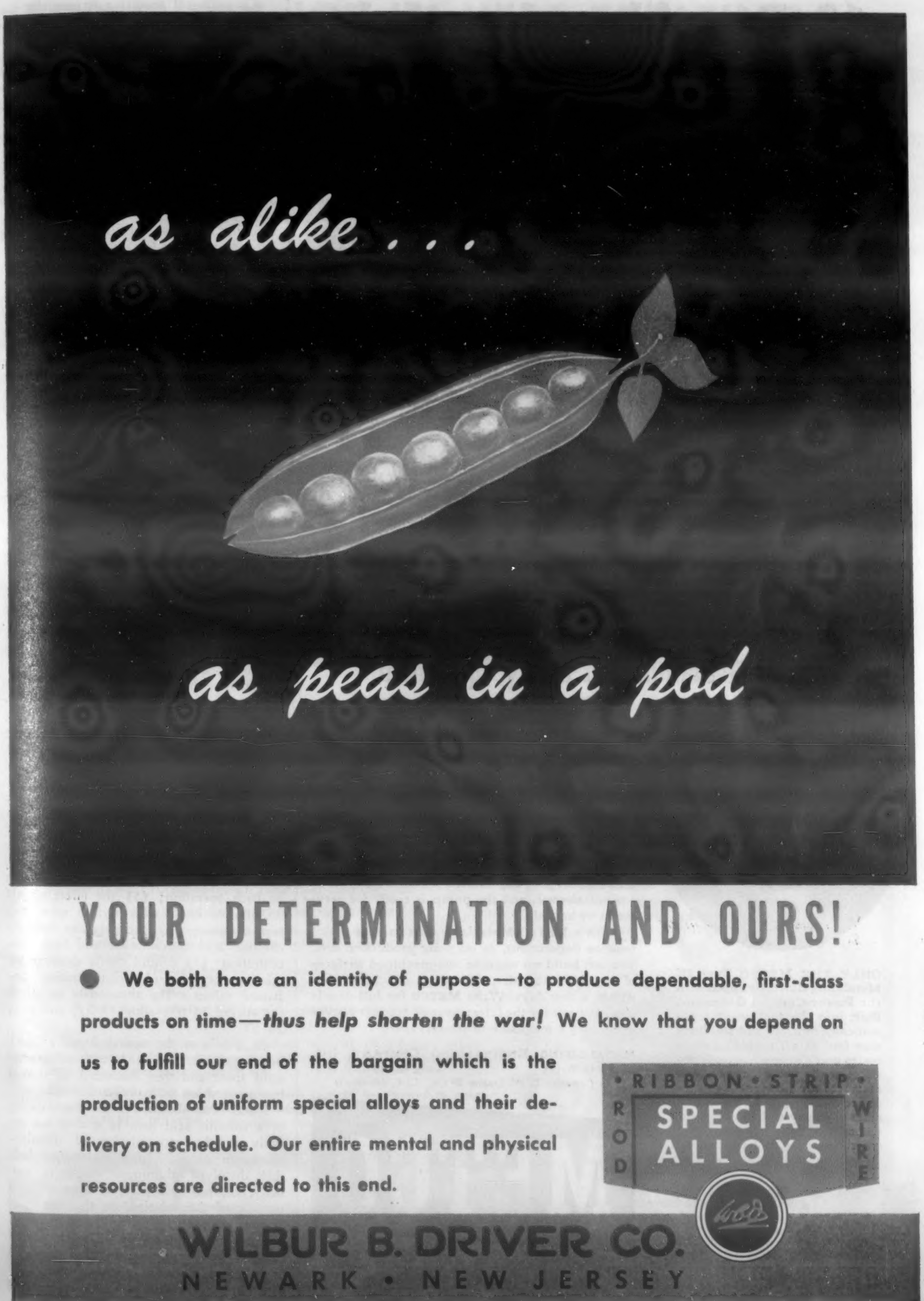
Limits of puckering expressed as $R'/t$, where $R'$ is spherical radius on the punch and $t$ is blank thickness, are the same for $R' = 3$ in. and $R' = 5$ in. The puckering tendency is decreased by increasing the spherical radius without changing the cup radius.

—William Schroeder & Thomas H. Hazlett, *S.A.E. Journal*, Vol. 51, May 1943, Trans. pp. 170-192.

## Chromic Acid Anodizing

*Condensed from "Proceedings," American Electroplaters' Society*

Increased production of airplanes has caused the problem of anodizing to become of vital importance. The chromic acid anodizing process is of particular importance because it is generally specified and it must be used on parts subject to stress or containing recesses in which the anodizing solution may be retained. Anodizing is done to provide a protective coating for the aluminum and to provide a surface to which paint will have satisfactory adherence. The anodic film is an aluminum oxide film formed by anodic oxidation of aluminum. Since the anodizing solution tends to dissolve some of the film, that part of the film which is on or near the surface is more porous than that in contact with the metal. The aluminum oxide which dissolves combines with chromic acid. As a result, as anodizing progresses and oxide dissolves, the amount of free chromic acid in the anodizing solution decreases and the pH of the solution increases.


as alike . . .
as peas in a pod
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We both have an identity of purpose—to produce dependable, first-class products on time—thus help shorten the war! We know that you depend on us to fulfill our end of the bargain which is the production of uniform special alloys and their delivery on schedule. Our entire mental and physical resources are directed to this end.
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Chromic acid anodizing is generally carried out in a steel tank containing a chromic acid solution of from 5 to 10 per cent concentration. The bath temperature is maintained at 95 deg. F. ± 5 deg. by heating or cooling coils, and the bath is gently agitated by air. Parts to be treated, after suitable cleaning and rinsing, are made the anode. The tank usually serves as the cathode. A low voltage direct current is applied at the start. The voltage is increased to 40 volts as rapidly as possible without overloading the generator or burning clamps or parts. Anodizing is continued for 30 min. The parts are then rinsed in hot water and dried.

Unfortunately, in most cases operators have not had available reliable information concerning the characteristics of the anodic treatment. This frequently resulted in wasteful and uncertain operation. Careful laboratory investigation of the quantitative factors of chromic acid anodizing indicates that, with proper procedure and two simple controls, greater throughput and uniform operation may be obtained while economies are effected in both chromic acid and power.

Certain general relationships are useful in understanding the operation of the anodizing bath. *e.g.*, the amounts of aluminum oxide dissolved and of chromic acid consumed are about proportional to the ampere-hours; high pH causes low current densities, low ampere-hours, and thin anodic films; low pH causes high current densities, high ampere-hours, and thicker films. The amounts of aluminum oxidized and of oxide dissolved increase with temperature and time. Anodizing efficiencies are better for pure aluminum and Alclad products than for the alloys.

Extensive data and charts are given showing various relations important in operating and maintaining an anodizing bath. These include: (1) The relations between film thickness and current density; (2) the relations between current density and pH; (3) the relations between film efficiency, weight of film, current density, amount of aluminum oxide dissolved, area anodized per lb. of chromic acid, and current used, at given constant pH values and at typical operating conditions; (4) variation of film thickness with temperature of bath operation; (5) the effect of pH on film thickness with various other factors constant; (6) the relations between chromic acid consumption and bath concentration; (7) control charts showing the relations between pH, concentration, and Baumé values. The above data are given for Alclad 24 ST, alloy 17 ST, and alloy 24 ST.

A bath may be operated on a batch basis, that is, operated without control until spent and then discarded, or it may be operated on a maintained basis.

It has been shown that the deterioration of a chromic acid bath is due almost entirely to the accumulation of dissolved aluminum oxide. In a maintained bath this dissolved aluminum oxide is partially removed by a periodic draw-off of a portion of the solution, so that the total amount removed by drag-out and draw-off is equal to that dissolved. The pH of the bath is kept approximately constant by periodic additions of chromic acid. A bath operated in this manner may be used

indefinitely. More uniform results are obtained than with batch operation, chromic acid consumption is less, interruptions in operation while making up new baths are eliminated, and disposal problems are minimized. Complete charts and directions are given for maintaining a bath by this method. The only measurements necessary are specific gravity (Baumé) and pH. Other practical aspects such as tank and rack design are discussed and illustrated.

—L. G. Tubbs, *Proc. Am. Electroplaters' Soc.*, 1942, pp. 122-132.

## Brittleness in Alloy Steels

*Condensed from "Stahl u. Eisen"*

As the cause of the tendency to temper brittleness is, in spite of intense research in this field, not yet fully explained, the literature was reviewed and new experiments made to solve the problem. Specimens were made of plain carbon and low-alloy steels melted in a high-frequency furnace, and hot-embrittlement produced by protracted annealing at 850 deg. F. leading to a more pronounced decrease of notch-impact toughness than cooling in "sterchamol" after tempering in the heat treatment.

The nickel, manganese, chromium and phosphorus contents exert an indirect influence on the embrittlement sensitivity of the steels inasmuch as they favor such sensitivity. The effect of phosphorus increases with increasing contents. Plain carbon and steels of low alloy content with the above-named elements show no embrittlement at low carbon contents; a minimum carbon content is necessary for the occurrence of embrittlement.

Molybdenum can reduce or even eliminate embrittlement sensitivity; the optimum molybdenum effect is obtained at a comparatively low moly content. Columbium does not have the same improving effect as molybdenum.

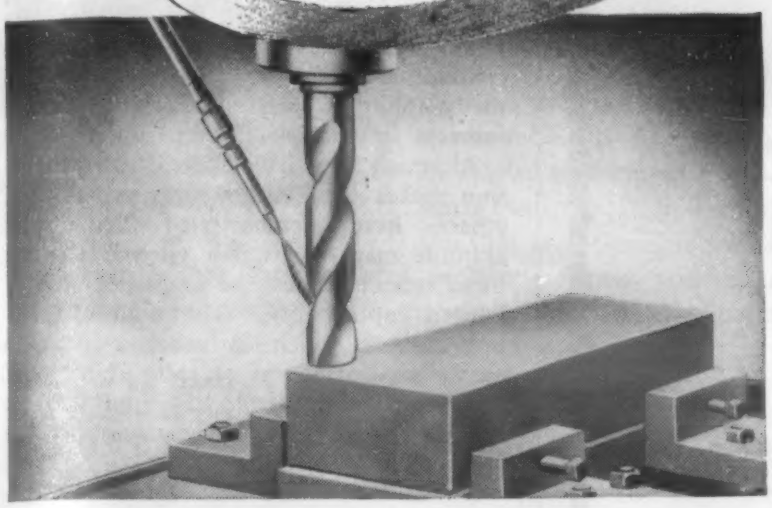
Higher quenching temperatures in hardening accentuate the subsequent tendency to embrittlement; the curve of embrittlement ratio (*i.e.* the ratio of notch-impact toughness in the tough original state to notch-impact toughness in the test condition) as a function of quenching temperature shows a very steep increase in a definite temperature range.

Speed of cooling during hardening exerts a certain influence inasmuch as slow cooling produces in steels of weak embrittlement sensitivity an increase, and in steels of strong sensitivity a decrease of tendency to embrittlement; steels of average embrittlement sensitivity show no such dependence.

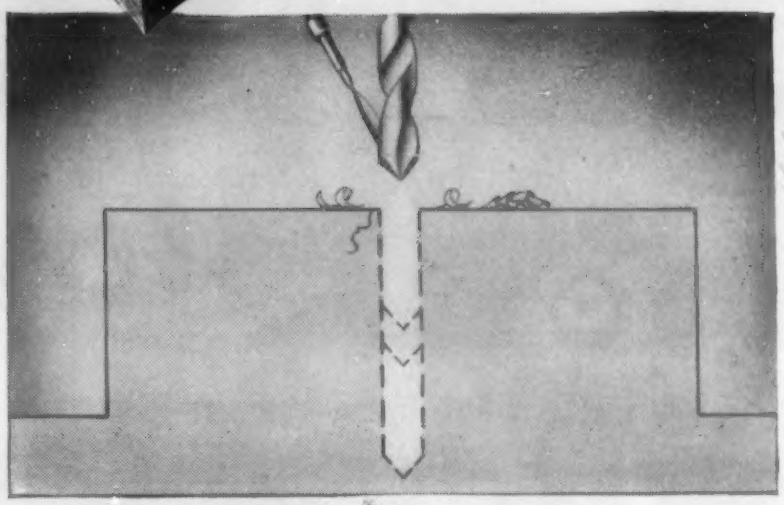
Annealing of long duration at temperatures below $A_1$ but above the critical embrittlement temperature range can considerably reduce the subsequent tendency to embrittlement, in agreement with previously published results. However, the investigations do not confirm the assumption that phosphide precipitation is a direct cause of embrittlement.

A comparison of a chromium-nickel-phosphorus steel with a strong tendency to temper brittleness and hot-embrittlement, with a copper steel having a tendency to precipitation hardening showed that both phenomena are different. In the

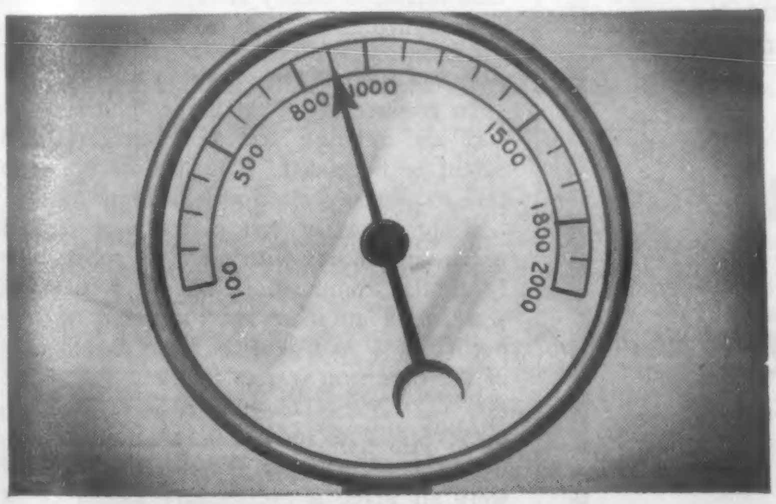
# Helpful Hints for Drilling Tough Steel



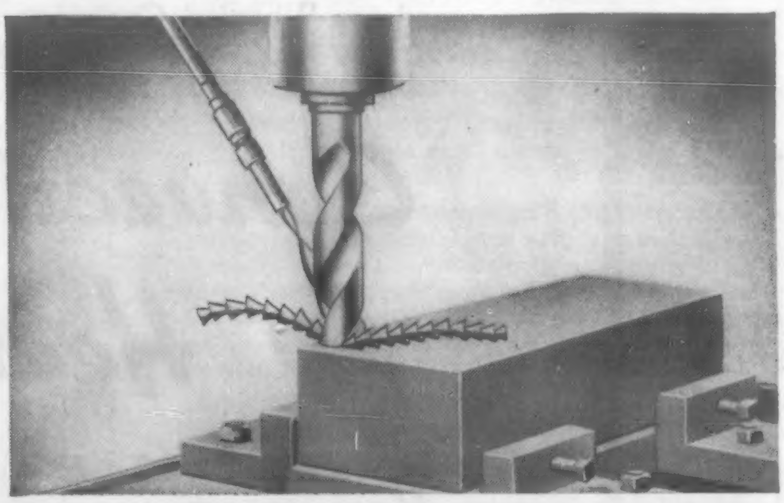
**1.** Use steady pressure and do not let drill ride without cutting. Back out the drill frequently to relieve chip congestion.



**2.** Back out when the drill has reached a depth three to four times the diameter of the drill for first insertion—one to two for second insertion—three to four for third.




**3.** To avoid drill breakage, always run at the proper speed. A 1/16″ center drill should run about 1800 r.p.m. (30 s.f.m.). A 1″ drill at 115 r.p.m. for same surface speed.



**4.** For deep drilling use a short spiral drill and Chillo No. 140 or 143, cut back with Amplex No. 00, further to reduce high temperatures. For shallow drilling use Chillo No. 90 or 93.

**5.** If you are faced with an unusual machining operation or if you are not satisfied with present results, call in a Cities Service lubrication engineer for consultation. His experience with Cities Service precision-made cutting oils on all kinds of machining operations is certain to help you as it has others. There is no obligation. For a copy of an informative booklet, "Metal Cutting Lubrication," write to Cities Service Oil Company, Room 1658, Sixty Wall Tower, New York 5, N. Y.

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discussion it was emphasized that not so much the temperature as the grain size should be considered, for with higher temperatures the grain size is usually coarsened.

—E. Maurer, O. H. Wilms & Kiessler, *Stahl u. Eisen*, Vol. 62, Jan. 29, 1942, pp. 81-89; Feb. 5, pp. 115-121.

## Enameled Iron

*Condensed from "Foundry Trade Journal"*

A great amount of fundamental research is necessary before cast iron can be fully developed as a base for resistant silicate coatings. The author emphasizes the importance of chemically-resistant enamels as applied to mild steel and cast iron.

The chemical composition of the base metal (cast iron) is really of only secondary importance. Given a clean casting, the microstructure is the all-important point. Troubles will be halved if the carbides are completely broken down and the graphite is precipitated in as fine a form as is practicable.

Although some have claimed that pearlite iron makes the best base for enamel and others have demonstrated that solid graphite may be given a vitreous coating, these results must be regarded as of limited applicability. The high temperature anneal which is usually given to enameling castings in order to "burn out" extraneous matter from the iron surfaces has the added effect of causing pearlite breakdown.

It was found that a fine graphite structure is advantageous and the more graphitization has progressed (pearlitic breakdown) before enameling the better. In a light casting this is attained by higher percentages of silicon and phosphorus, and free ferrite is nearly always evident in the microstructure of such an iron.

#### Effect of Alloy in the Base Iron

In engineering irons the graphitizing effect and refining action of certain alloys might be beneficial. The use of copper in this respect suggested possibilities.

Eight series of test plates were cast in green-sand molds with metal of substantially similar composition, but to each series was added an increased increment of copper (0.55% to 6% Cu). The composition of the base iron was as follows: T.C, 3.25; Gr. C, 2.55; C.C., 0.70; Si, 1.95; Mn, 0.75; S, 0.076 and P, 0.44%.

In accordance with convention the plates were all given a preliminary anneal under condition of standard time and temperature. After sand-blasting they received a ground coat. The cover-coats were fired on by the hot dust method at 1475 deg. F.

The unalloyed base iron plates gave erratic results and showed a distinct tendency to produce pin-holing and blistering defects. The plates containing 1 to 2% Cu enameled perfectly with a flawless finish and stronger adherence. It was determined that decomposition of the pearlite was practically complete in the case of the copper iron, while it had not progressed very far in the unalloyed metal.

The graphite in the alloyed iron is much finer in form and tends toward a supercooled structure. The indications are that graphite of this form is less liable to oxi-

dation in the enameling furnace. Some doubt has lately been thrown on this graphite-oxidation theory by some American workers, who postulated that dissolved hydrogen is thrown out of solution, at enameling temperature, into the graphite cavities, where a reaction may take place with formation of gas of the methane type.

Whether one accepts the hydrogen theory as being the genesis of pin-holing in cast-iron enamels or holds to the more classical ideas of the evolution of carbon oxides, it will be accepted that control of graphite size is a step in the right direction. Iron carbide will oxidize only in the higher temperature range, and therefore the evolution of carbon monoxide or carbon dioxide could be expected to occur only at elevated temperatures.

If hydrogen is the accepted cause, it is difficult to understand why diffusion does not occur at the lower firing temperatures. The hydrogen is not very soluble in ferrite, but is strongly bonded to the iron carbide. It may be that, at the critical point when the pearlitic carbide goes into solution in the austenite, hydrogen is released and diffuses to the surface.

### Why Copper Helps

From the author's tests on the adherence of silicate coatings to copper-containing cast irons the following deductions are offered: A thin film of copper oxide probably forms on the surface of the iron, protecting it from excessive oxidation and affording the enamel better grip. Copper, slightly in excess of the solubility limit (the real solubility of copper in commercial cast iron probably lies in the region of 1% or less, depending on the amounts of other elements present) in cast iron, gives just this very thin film of copper oxide which, as well as protecting the iron surface from excessive oxidation, gives better "wetting" of the metal surface and hence superior adhesion.

—W. Montgomery, *Foundry Trade J.*, Vol. 69, Apr. 8, 1943, pp. 279-283; Apr. 15, pp. 299-303; Apr. 22, pp. 329-332; Apr. 29, pp. 353-354

## Flange Welding Light Sheet

*Condensed from "The Iron Age"*

The Weibel Process of resistance melt-welding of thin gage sheet metals, especially of aluminum and magnesium alloys, is almost unknown in this country. The process has been in extensive use in Europe.

Welding heat is created by the flow of a.c. current through the welding joint between two carbon electrodes. The two carbon electrodes, having a diameter of 1/4 to 5/16 in. are clamped in an electrode holder at an angle of 90 deg. to each other. The electrodes are connected by two cables with a transformer having a capacity of 50 to 120 amp. and a potential of 5 to 8 volts.

Edges of sheets have to be bent up forming a flange 1/8 to 3/16 in. high. A commercial flux securing a clean fusion is used. Current passing through the flanges creates the heat to melt the flange metal and the two parts are welded together in a clean gas tight seam. In some instances a wire of the same alloy composition is placed on top of the flange to be melted down with it, thus strengthen-

This six year old Cyclone averages over 1500 tons of tempered parts per year at a maintenance cost of only 1c per ton!

# 6 year old CYCLONE averages 29½ tons of tempered steel per week!

IN JULY 1937, the gas fired Cyclone, shown above, started to turn out uniformly and accurately tempered parts at the rate of 9850 lbs. per day. The work was of various kinds and heated at different temperatures. Today, after almost six years of continuous service and the production of over 9,000 tons of work, this 22" diameter by 26" deep Cyclone is as efficient as the day it was installed.

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Bulletin 52, on the Gas Fired Cyclone Furnace, shows the wide range of sizes available, a cross section view showing the famous Lindberg recirculating principle, construction features and pictures of Cyclones at work on a wide variety of work. Bulletin 52 will gladly be sent on request. WRITE TODAY!

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ing the seam.

Points to be emphasized in order to make this process suitable for mass production are: (1) Equipment can be easily and quickly manufactured; (2) Welding may be done by hand or mechanically, and requires little skill after welding data have been determined; and (3) Magnesium alloys can be readily welded if a protective shield is used.

—W. Flatow, *Iron Age*, Vol. 151, Apr. 1, 1943, p. 539.

## Electric Salt Baths in Germany

*Condensed from "Schweizer Archiv"*

*This digest is based upon a translation of the original article, prepared by E. I. Valyi of Sam Tour & Co., Inc., whose kindness in making it available we hereby gratefully acknowledge. It suggests what German engineers are doing to cope with even more severe shortages than exist here. Unfortunately, the composition of the salt baths was not given.—The Editors*

In the past few years steels containing nickel have been almost completely eliminated from German usage. Chromium-moly steels were at first substituted, then abandoned in favor of the chromium-manganese steels now in wide use. Typical compositions of some of these "emergency" steels are EC 80—0.12-0.17 C, 1.1-1.4 Mn, 0.20-0.35 Si and 0.80-1.10 per cent Cr; VM 140 (a heat treating grade of 114,-000-135,000 p.s.i. tensile)—0.35-0.43 C, 1.0-1.3 Mn, 0.5-0.8 Si and 1.0-1.3 per cent Cr.

The chromium content in the absence of nickel causes the steel to scale and decarburize more readily, and makes them more susceptible to overheating and uneven timing. With the carburizing steels, excess massive retained chromium carbide may occur in the case, particularly with comparatively heavy case depth.

Salt bath methods are used to solve these difficulties. Carburizing is done in salt baths of the cyanide type, and hardening and drawing also.

#### Heat Treating Practice

The electric salt bath furnaces used contain electrodes placed very close to the wall at very short intervals along one of the longer walls, with the rest of the container volume practically free of electric flux. The current input remains nearly constant even if large work is charged. The electrode arrangement appears to be very favorable to avoiding cyanide decomposition, even at temperatures close to the decomposition point.

Furnaces up 2 meters (6 ft.) in depth have been used. Steel pots are used, lasting for 3,000 hrs. of continuous operation at 1700 deg. F.

A heat treating cycle for "emergency" steels includes hardening at 1600 deg., quenching and drawing at 600 deg. F. to 900 deg. F. as required. Carbon steels are quenched in water or oil, alloy steels in oil. Quenching in molten salt at about 400 deg. F. reduces cracking and warpage about 50 per cent over oil quenching.

Air convection type preheating furnaces are also used, bringing the work to 500 deg. F. to 800 deg. F. prior to transfer to the salt bath. The cycle operation

# In the reduction of metallic powders, INCONEL containers withstand over 2000° F. in complex corrosive atmospheres

The reducing of metallic powders . . . as a first step in the production of long-wearing, sintered-metal friction surfaces for brakes and clutches . . . imposes extremely severe conditions on the metal containers used in the process.

What these conditions are . . . and how they are met by Inconel containers . . . is shown by the experience of S. K. Wellman Co., pioneer in the field of powdered metallurgy.

When reducing metallic powders, the Wellman Co. uses Inconel cans, 20″ in diameter by 39″ high.

These cans are placed in an electric furnace where they are subjected to over 2000° F. for 72 hours.

*Complete furnace assembly used in reducing metallic powders is shown at left. At right, heating cover is off to show Inconel container over oxide charge. Cans, 20″ x 39″, are of .062 and .125 Inconel sheet, arc welded.*

Other destructive factors are present in addition to the high temperature.

The inside of the container is exposed to the action of carbon monoxide (reducing), carbon dioxide (oxidizing) and lead fumes (severely corrosive). The outside is exposed to an oxidizing atmosphere.

At first, steel cans were used; they lasted for only one 48-hour heat. Inconel cans, with Inconel covers, last for 50 to 75 heats —a total service of up to 5400 hours!

In addition to warping, the steel cans scaled, which affected the quality of the reduced metallic powders. Inconel's freedom from scaling avoids contamination.

An equally interesting performance by Inconel in the final phase of this Wellman operation . . . the "autodeous welding" of the sintered metal facing to a steel backing plate . . . will be described in a forthcoming issue.

---

* The details of this use of Inconel, a wrought nickel-chromium, heat-resistant alloy, are published in the belief that they will be of interest and value to engineers and designers working on similar problems, though the use of Inconel today is subject to conditions imposed by the War.

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***Sheet... Strip... Rod... Tubing... Wire... Castings***

is made automatic by arranging the salt baths in a circle around a column supporting radial arms, the work being carried by the arms, and moved by lifting, turning and lowering of the fixture. An electric timer controls its movements.

Carburizing is usually carried out at 1700 deg. F., lasting from one to six hrs. depending upon case depth required. Massive chromium carbides appear when long cycles are necessary, but are generally disregarded if the case does not materially exceed 0.04 in. With greater depths they may be eliminated by further heat treatment.

The work is quenched, preferably in a salt bath, after carburizing, and subsequently hardened by heating to 1500 deg. F. to 1550 deg. F. in a salt bath furnace and quenching in a salt bath. Core hardening must sometimes be added to this cycle.

**German High Speed Steel**

In the case of high speed steels the alloying constituents were considerably reduced. After some use of tungsten-molybdenum steel, the following low-tungsten composition was arrived at:

| | | |
|---|---|---|
| Carbon | 1.35 | per cent |
| Vanadium | 4.30 | " " |
| Chromium | 4.25 | " " |
| Tungsten | 11.50 | " " |
| Molybdenum | 0.90 | " " |

This steel is more susceptible to decarburization and to differences in heat treatment than the steels previously used, but these difficulties were overcome by use of suitable salt baths. The work is preheated to 750 deg. F. in an air convection furnace, further preheated to 1650 deg. F. in a salt bath furnace and hardened by heating to 2375 deg. F. in an electrode salt bath and quenching in a salt bath at 1075 deg. F. After air-cooling, the work is drawn in the last-mentioned quenching bath.

—C. Albrecht, *Schweizer Archiv*, October 1942.

## Surface Protection of Magnesium

*Condensed from "The Iron Age"*

Tests show that magnesium has excellent resistance to corrosion under normal atmospheric conditions. Corrosion is speeded, however, in surroundings having higher-than-average humidity and temperature.

Failure to achieve absolutely clean surfaces on parts to be chemically treated will result in unsatisfactory service and early failure of the protective coating. An easy test is to dip the part in cold water. If upon removal from the water, the surface is entirely covered by a film of water, then the surface is clean.

Any of the well known methods of solvent or alkali cleaning may be used to degrease magnesium, but cleaners of the strongly alkaline variety are the best. Alkaline cleaning may be accomplished either by boiling, or by a cathodic electrolytic process.

Alkaline cleaning solutions containing soap should not be used unless the magnesium is to receive a dichromate surface treatment. In cleaning surfaces that have been previously dichromated, soap-free sub-

stances should be used.

Chrome-pickle or acid dichromate dip treatment is most used when storing, shipping, machining or joining magnesium parts. The pickle consists of 1.5 lb. of sodium dichromate, 1.5 pt. of concentrated nitric acid and water to make 1 gal. The solution is usually used at room temperature. It may be revived by adding nitric acid.

Resistance of magnesium alloys to salt water is increased if parts are boiled in sodium dichromate. A dip in hydrofluoric acid before boiling in dichromate adds to the protective character of the treatment.

Galvanic anodizing method may be used for all magnesium alloys. It is a modification of the hydrofluoric acid-alkali-chromate treatment, and produces a uniform black coating and also makes a good paint base, as well as providing good protection against saline attacks.

Alkali-chromate treatment is satisfactory, when used on products which have been machined to fine tolerances. Coating resulting from this treatment is black or dark brown. Where it is important that the electrical resistance of the treatment be kept low, the chromate-sulphate treatment is used. This treatment does not provide a satisfactory paint base.

Chrome-alum treatment provides die castings with a decorative black finish which is a good paint base. A more uniform coating will result if the die casting surface film is first removed.

For finishing coats, phenolic resin varnish vehicles are the best. Highly satisfactory results have been obtained with aluminum pigments in a 20 gal., 100 per cent phenolic resin varnish containing quarter linseed oil and three quarter tung oil.

—S. H. Barmasel, *Iron Age,* Vol. 151, April 22, 1943, pp. 44A-44D.

## Reclaiming Precision Gages

*Condensed from "Steel"*

The tendency in electroplating is for plate to build up more on the edges and high points than on low points or the middle of flat surfaces. In building up worn gages to size, a deposit of accurate and uniform thickness is necessary.

Means for obtaining an even plate are proper design and arrangement of the anodes so that all parts of the work are equidistant from the corresponding anode area; use of shields to divert the direction of the current flow through the plating bath; method of racking the work; and use of "thieves," which are objects placed in contact with the cathode and close to the high points of the work or around the edges to rob them of the excess plating.

In the experimental work, attention was paid first to racking and "thieving." After the gage is properly racked and "thieved," it is dipped several times in a paint which resists the action of chromium plating solution. Paint is peeled from all surfaces on work and "thief" which are to be plated. The amount of exposed area is calculated as nearly as possible and the part is plated.

The procedure consists of electrocleaning 1 to 3 min. with forward current; electrocleaning 5 to 15 sec. with reverse current; rinsing; pickling 5 to 15 sec. in 20 per cent HCl; rinsing thoroughly; placing in plating bath in proper position with respect to anodes; applying for 30 sec. a reverse current of about 2.5 amp. per sq. in.; and plating at 2.5 amp. per sq. in. for predetermined length of time, with bath held at 55 deg. C. The plating solution consists of 33 oz. per gal. of anhydrous chromic acid and 0.348 oz. per gal. of sulphate radical.

Certain types of gages require specially designed anodes. For example, in plating the inside of a ring gage, it is necessary to place a circular anode through the center of the hole. The best progress to date has been obtained by having all exposed surfaces to be plated about 3 in. from the anode area perpendicular to the surface. No obstruction must come between anode and the work.

The proper design of "thief" is determined by trial and error, but calculations can shorten the process. More than one type of "thief" design can usually be employed, but each has optimum dimensions and distances from the work. These dimensions are varied until both "overthieving" and "underthieving" are obtained. By interpolation, the optimum dimensions and distances are usually obtained, although occasionally some minor changes have to be made.

Generally, the necessary plating time to produce the desired thickness is almost twice the theoretical value. To obtain the correct plating time, it was found that 30 sec. of reverse current at conditions given above removed 0.00004 in. of chromium or steel.

Gage-blocks are refinished by hand lapping them to 0.0002 to 0.0003 in. below their engraved measurement, but with an absolutely even surface. Blocks are then plated above their engraved dimension by 0.0001 to 0.0002 in., with the difference between the highest and lowest spot of the plate not more than 0.00005 in. The gage is then hand lapped to the proper dimension. Pin gages, plug-gages, and taps can be repaired by using a somewhat similar technique. All gages repaired by this method last 3 to 5 times as long as new unplated ones.

The two most important factors for success in this work are proper design of the "thieves" and accurate control of the current-density. A separate current control for each device or group of devices is highly desirable.

—William Irby, A. T. Clarke, and F. R. Grover, *Steel*, Vol. 112, April 26, 1943, pp. 86-88, 90-92.



## Machining the NE Steels

*Condensed from "Metal Progress"*

National Emergency steels on the high side in critical alloys are destined for replacement by the leaner types, consisting essentially of the NE 1300 series (carbon-manganese), NE 8020 (manganese-molybdenum), the 9200 series (silicon-manganese and silicon-manganese-chromium steels) and the 9400 series (manganese-silicon-chromium - nickel - molybdenum). It is doubtful if the NE 1300 steels will be available long for general use.

### Three Classes

The NE steels may be divided into three general classes:

1—Carburizing steels containing up to 0.28 per cent C, used where the finished part is to have a hard wearing surface and good toughness and shock resistance in the core. They may be machined in the hot rolled, annealed, or cold finished condition. Cold finishing improves their machinability.

2—"Semi-through hardening" grades containing from 0.28 to 0.40 per cent C include water hardening and oil hardening types. They are generally used for parts requiring from 100,000 to 150,000 lbs. per sq. in. tensile strength (Brinell hardness range from 200 to 300). Some are used in the normalized, or normalized and tempered conditions, with tensile strengths of 65,000 to 105,000 lbs. per sq. in. They are best machined in the normalized or annealed condition.

3—"Through hardening" grades, containing more than 0.40 per cent C, all oil hardening, are divided into those treated to Brinell hardnesses of (a) 550 to 600, and tensile strengths of 275,000 to 300,000 lbs. per sq. in. (b) 350 to 450, with tensile strengths of about 175,000 to 225,000 lbs. per sq. in. (c) 260 to

350 with tensile strengths of about 125,000 to 170,000 lbs. per sq. in. and the high-carbon 5200 series used for ball and roller bearings, at the maximum hardness obtainable for the section involved. All are best machined in an annealed condition, preferably with a spheroidized structure.

Manufacturers are not unanimous but in general NE steels seem to compare favorably as to machinability with the former A.I.S.I. or S.A.E. steels. Case histories show the following substitutions have been made in various plants with little distinction in machinability between the old and new materials: NE 8024 (manganese-molybdenum) for S.A.E. 3115 (nickel-chromium); NE 8620 for S.A.E. 4620 and S.A.E. 4615; and NE 8720 for S.A.E. 4820. An improvement in machinability was found in the substitution of NE 8720 for S.A.E. 4815, and S.A.E. 4620; and NE 8724 for S.A.E. 4820 (high Ni-Mo).

### Cutting Tools

For the NE steels cutting tools of high speed steel are adequate. An appropriate shape of turning tool is as follows: 8 deg. back rake, 14 deg. side rake, 6 deg. end relief, 6 deg. side relief, 6 deg. end cutting edge angle, and 15 deg. side cutting edge angle. The nose radius should be large, but not in excess of 10 or 20 per cent of the depth of the cut used. Cemented carbide tools may have: A back rake angle of from 0 to 5 deg., a side rake angle of from 5 to 10 deg., side and end relief of 5 deg., an end cutting edge angle of 6 deg., a side cutting edge angle of from 0 to 15 deg., and a nose radius of 1/32 in.

Standard drills and milling cutters can be used with rake angles from 10 to 15 deg. on the milling cutters. In threading, a rake of from 10 to 15 deg. will give good results with chip space or flute ground smooth to a full radius.

Emulsions of soluble oils are satisfactory for turning, milling and drilling when high cutting speeds are employed. For low speeds as in broaching, reaming and threading, sulphurized mineral oils should be used or, as a substitute, mineral oil plus from 10 to 15 per cent fatty oil. Cutting fluids should be at a low temperature, applied in large quantity and at high velocity.

One progressive firm believes that anything can be machined. Tool angles, cutting speeds, and ratio between depth of cut and feed will have to be adjusted to produce the most favorable results.

—O. W. Boston, *Metal Progress*, Vol. 43, April 1943, pp. 543-547.

## Joining Metals with Adhesives

*Condensed from "Light Metals"*

A brief description is given of the "Redux Process" which provides, through the use of synthetic resin adhesives, a method of bonding light alloys to light alloys or steel to steel with a strength exceeding, under certain conditions, that of riveting. The development of the process may prove to be as significant as the introduction of the resin adhesive to the plywood industry.

Basically, the process is a method of resin bonding applied by a technique involving accurate control of variables, but adaptable to the nature of the surfaces to be joined. Details cannot be released at present.

The method enables light alloys and steel to be cemented together, or to wood, without stress concentrations, to give joints that are aerodynamically smooth, gasoline tight and stronger than riveted joints. The method is said to be economical and lends itself to modern production methods. The synthetic resins employed are unaffected by water, oil or gasoline.

The process works best with trivalent metals such as aluminum, chromium or iron and steel; it gives less satisfactory results with brass, tin and zinc. The resin bond loses strength at temperatures above 200 deg. F. The process gives strong joints between metal and wood and meets design requirements arising out of existing trends in aircraft construction.

Graphs showing the effect of temperature and sheet thickness on the strength of the joint are given with sheet gages commonly employed in aircraft, the failing stress exceeds 2,000 lbs. per sq. in. at temperatures up to 160 deg. F. The joints do not become brittle below the freezing point.

—*Light Metals*, Vol. 6, May 1943, pp. 219-221.

# Helping to Solve Today's Wartime Production Problems

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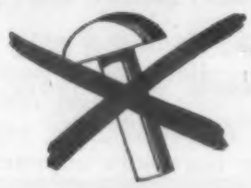

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Once the proper pressure, current and timing has been set, the operation (by a convenient foot switch) is fully automatic. The settings are easily made on the sequence panel by the adjustment of the maximum current relay and the pressure gauge.

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**TYPE PMCR.2516 SCIAKY ELECTRIC RESISTANCE ROCKER ARM WELDER,** welding 70 spot welds per minute, on two sheets of aluminum alloy of .040" each. Welding capacity from two thicknesses of .016" in aluminum alloys up to and including .080".

*right*

**TYPE PMCO.2516 SCIAKY ELECTRIC RESISTANCE WELDER,** 80 spot welds per minute on two sheets of light alloy of .040" each. Welding capacity from two thicknesses of .016" each in light alloys up to .091".

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# Materials and Engineering Design

# 4

*Engineering Properties of Metals and Alloys • Resistance to Corrosion, Wear, Fatigue, Creep, etc. • Engineering Design Problems of Specific Industries and Products • Selection of Metals, Metal-Forms and Fabricating Methods • Non-Metallics in the Metal Industries • Applications of Individual Materials • Conservation and Substitution*

CONTENTS



## Aluminum in the Brewing Industry

*Condensed from "Light Metals"*

Aluminum has long been recognized as a safe and suitable constructional material in the brewing industry and is utilized at all stages from the initial fermentation process to the final distribution. [In the U.S.A. no aluminum is available for brewing equipment, but the information in this article may be of interest to those thinking in terms of the future.—Editor]

Broadly speaking aluminum is the safest and most suitable metal for the brewing industry, it gives long life and efficient processing and is harmless to the product.

The obvious competitive materials, wood, glass, glass and vitreous enamel linings, stoneware or plastics are inferior to aluminum in some respect.

Wood has a very limited life and cannot be readily cleaned. Glass is an inert material, safe to use in the brewing industry. It is readily cleaned but it's fragile and not so amenable to fabrication. Weakness under shock or sudden temperature change is a serious drawback. Glass-lined containers have proven very successful but they too fail readily under mechanical impact. Vitreous enameled steel or cast iron fall into the same category. Earthenware has similar objections to glass—in addition it is massive and heavy for installation and forms and shapes are restricted.

According to the scanty information available, certain types of thermoplastics are making some headway in the field of brewing equipment. Polyvinyl chlorides and polyvinylidene chlorides deserve special mention. Their resistance to heat is limited, 160 deg. F. being the maximum temperature.

Some few years ago the Dansh Aluminium Industrie Ltd. (Copenhagen) issued literature on the use of aluminum in the brewing industry. They found that the weak acids formed during the fermentation of wort do not attack aluminum, but sour acid beer is corrosive to the metal. Yeast is inert, neither attacking aluminum, nor itself being affected.

Alcohols, provided they contain a trace of water (.01% or more) are safe toward aluminum. This includes not only methyl and ethyl alcohols, but the higher members, propyl, butyl and amyl. They must not, however, contain traces of alkali or acid.

Spirits, liqueurs and wines require special consideration as tests have indicated that alcoholic beverages embracing whisky, brandy, rye whisky, gin, cognac, apak and the like react with unprotected aluminum with the formation of a flocculent precipitate of aluminum hydroxide. The product is dissolved and the flavor affected.

Anodic oxidation of aluminum provides a satisfactory solution to the problem, protecting the aluminum and preventing the deterioration of the product.

With wines, variations in the composition from one vintage to another make generalizations dangerous. Heavy white wines, containing free sulphurous acid, are affected by aluminum; on the other hand, wines low in pectic acid are virtually unaffected.

### Some Precautions

The unsuitability of unprotected aluminum for contact with the finished spirits is partially due to the presence of acids such as tannic acid derived from wooden casks, particularly oak, in which earlier processing is carried out.

It is stated that aluminum of 98 per cent purity has an adverse effect on cider and that with copper-containing aluminum alloys deterioration is more marked. Earlier failures of aluminum were probably due to the use of lower grades of metal.

The fact that aluminum can be fabricated readily and also that the possibility of sudden leakage can be ruled out has led to the recognition that this light metal is most suitable for brewing plant and equipment. No taste, smell or color is imparted to the liquids with which it comes in contact.

The metal must be suitably isolated from materials likely to cause corrosion, such as concrete or new brickwork and from other metals such as steel, copper or lead. The life of an all aluminum brewing plant is long and if it must be scrapped because of expansion or process changes, the metal has a high scrap value.

Prolonged contact between beer and aluminum vessel causes the formation of a glaze of "beerstone." This is per-

fectly harmless and protects the metal. For disinfecting aluminum plant and fittings a formalin solution is recommended. The use of mercury thermometers with aluminum equipment is to be avoided.

—*Light Metals*, Vol. 6, May 1943, pp. 209-219.

## New Aircraft Engine Materials

*Condensed from "S.A.E. Journal"*

Aircraft engines will soon have a new set of alloy-steel compositions for the majority of working parts. These tools have been selected by the SAE Aircraft Materials and Processes Coördinating Subdivision from the National Emergency series and have been incorporated in Aircraft Material Specifications and are designated as AMS alternates.

Substantial savings in nickel and chromium will be made through use of these steels in aircraft engines, but more molybdenum will be used. By combining the effects of all three of these elements, the new steels will require smaller percentages of alloying elements but will have the same physical properties as the old steels. Hardenability tests show that the hardenabilities of the alternate steels approximate those of the superseded steels.

Fatigue tests indicate that for standard polished specimens, the fatigue limits of the new steels average about 50 per cent of the ultimate tensile strength, while specimens notched after heat treatment average about 15 per cent of the ultimate. These values compare favorably with those for the old steels. At temperatures as low as —65 deg. F., there is no dangerous drop in the impact properties of either the new or the old steels.

Tentative machinability tests have indicated that the alternate steels in both the carburizing and non-carburizing grades will probably have machining properties equal or slightly superior to the present steels.

Comparison of the carburizing characteristics of an alternate steel and of the steel it replaces shows that the former has a somewhat slower carburizing rate but a higher surface hardness. The difference in carburizing rates will not cause any important increase in carburizing times in production. Preliminary tests indicate that distortion in heat treatment will probably be about the same with the new steels as with the old.

Baffles on an air-cooled engine are now made of a cotton fabric impregnated phenolic resin plastic. They save about 29.5 lbs. of aluminum formerly used for this purpose on the average engine, give better service, and show less breakage. Plastics are also used for push-rod housings and save 4 lb. of aluminum. Aside from these, use of plastics for major parts in engine construction appears limited because of temperature and stress conditions encountered.

Silver is being used satisfactorily as a bearing material. Master rod bearings, now of silver, exhibit higher fatigue strength, better heat conductivity, and a greater load carrying capacity than the


The Day Will Come
In a comparatively short time, as history goes, this war will end. On that shining day when industry will resume the manufacture of peace time products, this organization will also be ready to divert a tremendously accelerated output of wrought Phosphor Bronze, Nickel Silver and Beryllium Copper into its normal channels; these metals, in the manufacture of which we have specialized for many years, will again be doing the jobs that only they can do with fullest effectiveness.
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copper-lead bearings formerly used.

Metal surfacing is being used increasingly for a variety of purposes. Electrodeposited silver coatings and phosphate coatings to prevent chafing or fretting between adjacent steel surfaces have eliminated failures in certain parts. Sintered bronze clutch plates treated with sulphur-bearing compounds have shown an improvement in break-in quality and do not weld under severe operation.

Hot aluminum spray is used extensively on air-cooled engines to replace paint, resulting in improved corrosion resistance for engines operating near salt water. Zinc shows promise as a substitute for cadmium in protecting many engine parts against corrosion, but sufficient service information is not yet available to state that it will be satisfactory. Zinc-coated lock-wire to replace stainless steel has given trouble when the soft zinc is skinned from the wire at installation by pulling through studs.

A substitute aluminum alloy for cast cylinder head material (AMS 4220) contained iron in place of the 2 per cent Ni. Laboratory tests indicated satisfactory properties, and casting properties were equivalent to the old, but every cylinder head used in an engine cracked. The field for new materials is now limited. Demands are dictated by production requirements rather than by performance.

—Mel Young & Herman H. Hanink, *S.A.E. Journal,* Vol. 51, May 1943, Trans. pp. 157-164.

## Spot Welds in Fatigue Service

*Condensed from "Welding Journal"*

Due to inability to use static tests for determining dynamic performance, studies were made in fatigue in standard Krouse sheet metal fatigue testing machines. The test specimen consists of a single spot weld in two pieces of sheet of 16 gage max. thickness. The specimen is 1 in. wide with an overall length of 3-3/8 in. The materials tested were Cor-Ten with 55,000 yield and 75,000 ultimate strength, and 18-8 cold rolled to 120,000 ultimate strength. A program of varied welding current was used to provide specimens which were tested in shear, for tensile strength, impact and endurance limit.

For both Cor-Ten and 18-8 the fatigue strength first decreased with increased welding current, then increased due to the larger weld area. For Cor-Ten with timing of 4 to 20 cycles the lowest timing gave optimum fatigue values. With excessive heat in longer timing the 18-8 also developed lower fatigue strength. The fatigue values do not parallel the static test data or impact.

There is considerable discussion of the location of fatigue fracture and many micros are shown of the cracks. Notch effects do not always influence location of fatigue fracture since in the case of Cor-Ten the notch area is in the heat affected zone which has been hardened and strengthened sufficiently to cause the maximum stress to fall outside of the notch area. In the 18-8 welds the weld and heat affected

zone have lower strength than cold rolled base metal, therefore fatigue failures are predominantly located at the notch in the jointed sheets.

—A. M. Unger, H. A. Matis and E. P. Gruca, *Welding Journal*, Vol. 22, Mar. 1943, pp. 135s-142s.

## Cracking of Zinc-Plated Steel at High Temperatures

*Condensed from "Monthly Review," American Electroplaters' Society*

Zinc plating must not be allowed in contact with any stressed steel part (particularly in aircraft) which operates at temperatures above 700 deg. F. Evidence is given that under these conditions zinc rapidly penetrates the grain boundaries of the steel, causing cracking to occur. At 1400 deg. F. crack development is very rapid. This effect is noted in stainless steel, some low carbon steels, SAE 2330 aircraft bolt steel, SAE 4130 steel and in every other steel tested by the author.

Attention is called particularly to the danger in the possibility of aircraft repair mechanics using zinc plated repair bolts in aircraft engines. Cadmium does not have this effect on steel and must be used on all aircraft parts which operate at elevated temperatures.

[A Navy Department directive requiring the substitution of zinc plating for cadmium plating has been recently modified, in recognition of the above facts, to permit the use of cadmium plating on parts that must be operated above certain temperatures and under other stated severe service conditions.—Editors]

—Franklin Page, Jr., *Mo. Review, Amer. Electroplaters Soc.*, Vol. 30, 1943, pp. 436-438.



## Carbon Steels Replace Alloy

*Condensed from "The Iron Age"*

Substitution of alloy steels by plain carbon steels presents numerous manufacturing problems. Chief cause is the lower hardenability of plain carbon steels which necessitates the use of water and refrigerated brine as coolants. This brings an increased cooling rate which may result in cracks in the treated part and increased distortion.

Buying plain carbon steel for heat treated parts requires knowledge of metallurgy as the specifications for plain carbon steel for carburizing must contain more information than is usually required for alloy steels. It is insufficient to order plain carbon steels by symbol number only as most specifications do not include a silicon range which is necessary for satisfactory carburizing properties. Grain size should also be specified.

Where silicon content is low, which would often represent a heat containing a high percentage of oxygen, since deoxidizers other than silicon may be used, there is a wide variation of surface hardness. The presence of oxygen is usually determined by the McQuaid-Ehn test, which involves a microscopic examination of the condition of a carburized and a slowly cooled area, and classification by the condition of the pearlite areas which in a normal steel are found close to the carbide network.

It is possible to minimize or perhaps eliminate this abnormal pearlite condition by quenching parts in refrigerated brines. Improvement is accomplished not only by the increased cooling rate, but also by the effectiveness of the brine solutions in preventing the formation of steam or vapor pockets on the surface of the steel during the first stage of quenching.

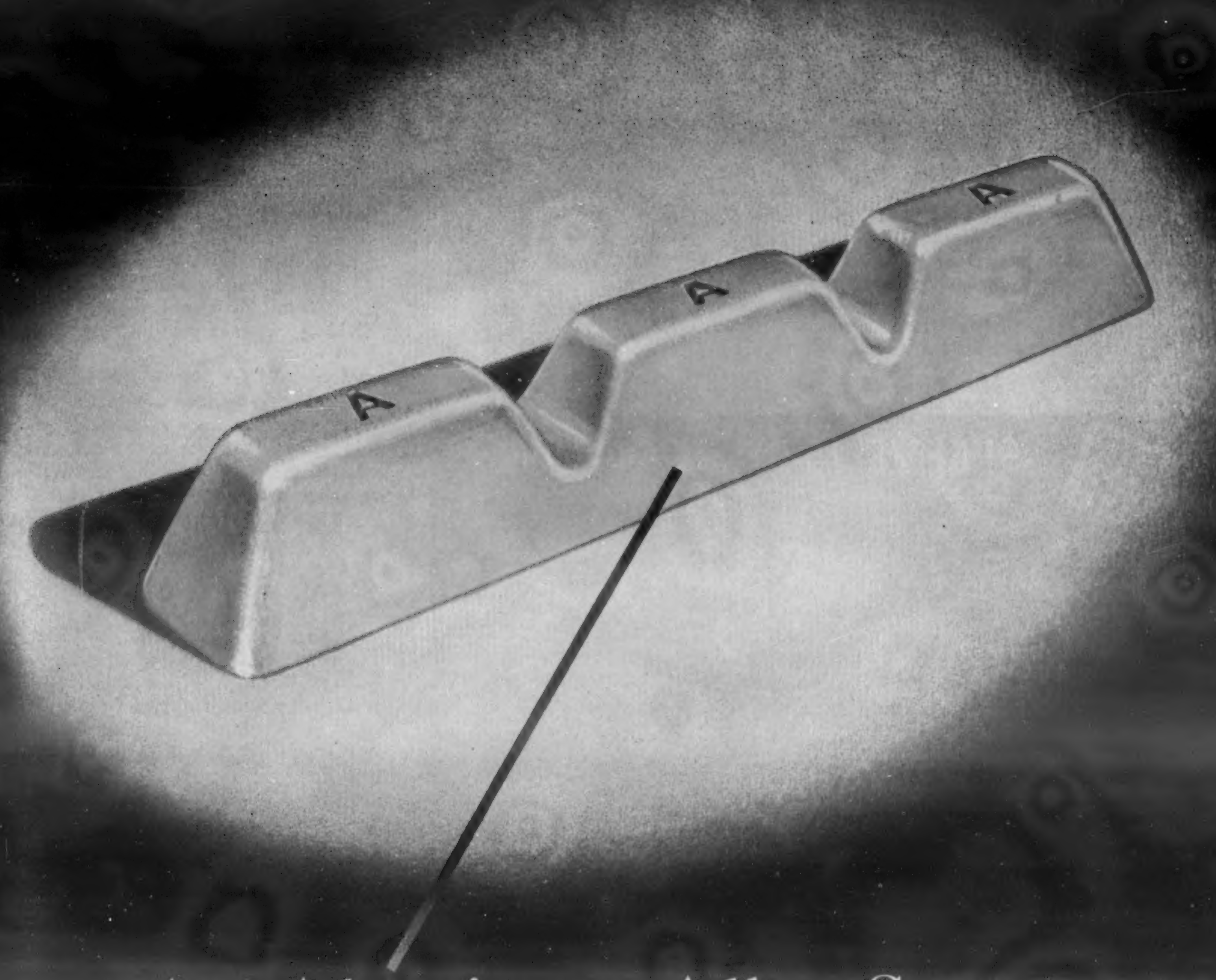
By grain size is meant the grain size after carburizing steel for 8 hr. at 1700 deg. F. The practice and manner of rating is covered by ASTM E-19-39T.

Though coarse grained steel can be cooled at a slower rate and yet produce the same hardness as a fine grained steel, coarse grained are not necessarily the most popular choices for carburizing steel.

This type of steel has a greater tendency to have surface seams. Also, a more brittle structure is often encountered in hardened parts due to enlarged grain size. On the other hand, a fine grained steel AISI C-1015 is so much inferior in hardenability.

It appears desirable to increase the manganese content of fine grained C-1015 to offset the reduced hardenability over coarse grained C-1015. This means the selection of AISI C-1022.

The effect of manganese on a 1-in. round, 3-in. long, quenched in cold water at 1650 deg. F., and which has a cooling



rate at the center of about 100 deg. F. per sec. at 1300 deg. F., shows a hardness of 29 Rockwell C, for a steel containing 0.85 Mn and 17 Rockwell C for one containing 0.50 per cent Mn. This difference in hardenability would be evident in the core of the carburized and hardened part.

Comparing the plain carbon steel under the most favorable conditions, that is, using AISI C-1022 with 0.70-1.00 per cent manganese range and chromium of 0.14-0.19 per cent, there is a wide gap in hardenability between this steel and previously used alloy steels such as AISI A-4119, and AISI 4620.

It is probable that plain carbon steel, C-1022, can be used in many places where an alloy steel is now used, and the difference in hardenability can be compensated for by water quenching where parts of not too large a section are reheated after carburizing. It cannot be used for parts direct quenched from the carburizing heat, for water quench would be too severe. In parts that are being made from C-1022 the largest solid section is about 15/16 in. in diameter. Parts are case carburized at 1700 deg. F.

There is no reason for any extension of carburizing cycles in changing over from alloy steel to plain carbon steel, nor is there any reason for concern over the carbon distribution characteristics of the case if the plain carbon steel is of the proper quality.

By suitable selection of steel, however, parts made from AISI C-1045 can be oil quenched in sections of 7/16 in. and under to produce satisfactory surface hardness, although in a 7/10 in. section of the maximum tensile properties are not developed throughout the section.

A slight increase in carbon content to AISI C-1050 does increase hardenability to a point where a 5/32 in. section can develop maximum properties after oil quenching and give a satisfactory hardness up to a 5/8 in. section.

Problem of where to draw the line dividing water from oil quenching has been a serious one. Therefore, plain carbon steel must be purchased under rigid specifications and with careful planning, requiring knowledge of application and type of heat treatment required.

AISI list gives a number of steels within range of 0.32 to 0.50 per cent C that are known as medium carbon grades. Effect of the carbon content on hardenability data were obtained from standard end quench specimens quenched from 1550 deg. F.

A fairly good idea that 45 Rockwell C in the as-quenched condition will produce satisfactory physical properties was drawn from information obtained from quenching a 3 in. round, 9 in. long made from A-3140 steel quenched in water from 1550 deg. F.

As to the grain size, a coarse grain has a marked effect in increasing the hardenability, thus enabling large sections to be hardened. This is important in oil quenching. For water quenched parts a fine grained steel is preferable, because it shows less distortion.

A slight amount of chromium improves the hardenability of medium carbon steel. When 0.14 to 0.19 per cent is present, it has an effect equal to the effect of changing from fine grain to coarse grain steel.

Carbon steel containing 1.48 per cent Mn, as far as hardenability is concerned is at the lower end of the alloy class, equaling in hardenability an A-4042 molybdenum steel, which means that this analysis can be hardened by oil quenching.

Where the section is hardened throughout, a carbon steel maintains the same relationship of hardness to tensile strength as does an alloy steel. Also, under the same hardening conditions yield strengths are the same.

Advantage of alloy steel mainly lies in its ability to harden throughout in larger sections. Also, for a given tempering temperature the alloy steel is harder.

Nickel, when added to carbon steels has a marked effect on elongation and reduction of area values, especially in the higher hardness ranges. Chromium and manganese have lower values, as also do combinations of chromium and molybdenum and manganese and molybdenum. However, they have improved resistance to softening by tempering. The effect is desirable in many applications.

—A. S. Jameson, *Iron Age*, Vol. 151, May 6, 1943, pp. 47-56; May 13, 1943, pp. 59-65.

# CO-6

**TYPICAL ANALYSIS**

| C | W | Cr | Va | Mo | Co |
|---|---|---|---|---|---|
| 88% | 5.50% | 4.00% | 1.75% | 4.50% | 9% |

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In every plant there is a tough machining job where Tungsten Cobalt High Speed Steels were formerly used. Nowadays, however, they are rapidly being replaced by the Tungsten-Molybdenum-Cobalt type, such as Latrobe's CO-6, with excellent results.

You'll find that CO-6 equals, and in many cases exceeds, the performance of the 9% Cobalt Tungsten types. CO-6 is ideal for machining armor-plate, lathe beds, tank-rings, bearing races, car wheels, locomotive tires and other heavy-duty cutting applications where hardened or semi-hardened parts are involved. In ordering, unlike the Tungsten types, CO-6 need not be balanced with any other steel.

Heat-treating is simple. There is no danger of decarburization in hardening. CO-6 will prove tougher for many uses and provide cutting edges without any tendency to flake.

**EASY TO HEAT-TREAT**

Preheat at about 1450°F;

Harden at 2220° to 2260°F;

Quench in oil or air.

Double-draw at 1050°.

Our metallurgical staff will be glad to advise on the adaptability of CO-6, described in our new technical bulletin. Write for your copy.

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*CONTENTS*



## FeO in Steelmaking Slags

*Condensed from "Blast Furnace and Steel Plant"*

The FeO of the slag and the carbon of the metal are by far the most important factors which control the oxygen content of the metal. The value oxygen divided by FeO is the factor by which the FeO in the slag must be multiplied to give the oxygen in the metal. This factor varies with the carbon content of the metal. A chart showing this relation has been prepared and it eliminates multiplying.

Bath oxygen is a fairly reliable indication of the amount of aluminum required for killed steel. A deoxidation guide is made for each grade of steel. In practice, this is a two-way table based on carbon and FeO.

The effect of metal oxidation is obscured by so many other factors that in itself, it is no improvement over a straight schedule based on slag oxidation for indicating the ladle deoxidation required for rimmed steel. Apparently carbon variations have a combined effect, one involving the oxidation and the other influencing rimming action.

For determining the amount of aluminum to add to rimmed steel, the following equation is used:

$$\text{Al} = \text{K} \times \frac{\text{H. P.}}{\text{S.P.}} \times \text{FeO} + 1 \text{ lb. Al } \frac{300\text{-X Mn}}{100} + 3.5 \text{ lb. Al } \frac{0.08\text{-YC}}{0.01 \text{ C}} + 1 \text{ lb. Al } \frac{\text{Tap Temp.} - 2915}{5 \text{ deg. F.}}$$

in which, K is an empirical factor for mold size; H.P. is the height of pour in inches; S.H. is 70 in. (standard height of pour); X, manganese is the ladle addition of manganese; YC is the carbon at tap; and Tap Temp. is the tapping temperature of the heat, varying with the carbon content less the minimum skulling temperature for that grade of carbon steel.

For any given specification, the many factors influencing manganese efficiency can be combined into a simple empirical relation between preliminary manganese and FeO. Within the limits of a charge based on a flush slag and 2 per cent Mn in the iron, the relation between preliminary manganese (0.06-0.20 per cent) and FeO in the slag can be represented satisfactorily by a straight line. Within these limits the equation of this line is FeO + 100 Mn = 32. If the total is over 32, the FeO is considered high for the given manganese. If the total is lower than 32, the FeO is less than normal.

—F. G. Norris, *Blast Furnace & Steel Plant*, Vol. 31, April 1943, [supplement] pages 41-42, 44, 46, 48.

## Inspection of Ordnance Castings

*Condensed from "The Iron Age"*

A vital phase in the production of ordnance castings is inspection. Seemingly small defects from the viewpoint of an ordinary commercial casting may be passed or filled with a weld, whereas this is not authorized by the ordnance department. Sometimes obviously serious defects are missed.

A large number of alloy steel castings with a polished and flame hardened working surface have been found to have unauthorized welds. The fact that the weld could not be satisfactorily hardened meant only less wear resistance.

The ordnance department has streamlined its inspection procedure without sacrificing quality. By adhering to the following points, the foundry should suffer no interference with its production schedule: (1) Copies of the order should be forwarded to the ordnance district by the prime contractor; (2) The foundry should have blueprints, specifications, and proper test bar patterns; (3) Contact the prime contractor for approval of changes in pattern and casting; (4) Notify the local ordnance office sufficiently in advance for inspection.

All orders must specify fully the type of metal required. When a specification is sub-divided, the composition number or class must also be stated. Every foundry should also have Federal specification

Q Q M-151a on inspection of metals, in addition to the specification covering the product in question.

Chemical rejections of steel are much greater than of non-ferrous metals. Here analysis depends entirely on foundry practice. Lack of cupola control may result in hot and cold converter blasts, leading to later difficulties. This can be checked by wedge or chill test on each ladle. Gray iron is usually specified on a physical basis only, and is rejected for low physicals. These can be raised by lowering the carbon or both carbon and silicon.

If the test piece is not attached as a coupon or an integral part of the casting, it is necessary to have a correctly designed test bar. In cases like manganese bronze, where special test patterns are necessary, they are illustrated in the specification.

If a metallographic test is required the foundry should be supplied with a standard micrograph, illustrating a suitable structure. When possible the entire cross section will be taken.

When X-ray tests are specified they are usually used to establish correct molding technique. On accomplishing this, the X-ray test is either eliminated or used only as an occasional check.

Without specific permission from the inspector, defects must not be welded. Any unauthorized welds are subject to rejection, since the inspector does not know what lies below the weld. This article includes a casting defect chart.

—A. C. Richmond, *Iron Age,* Vol. 151, April 22, 1943, pp. 41-44.

## Visual X-Ray Examination of Light Alloy Castings

*Condensed from an American Foundrymen's Association Paper*

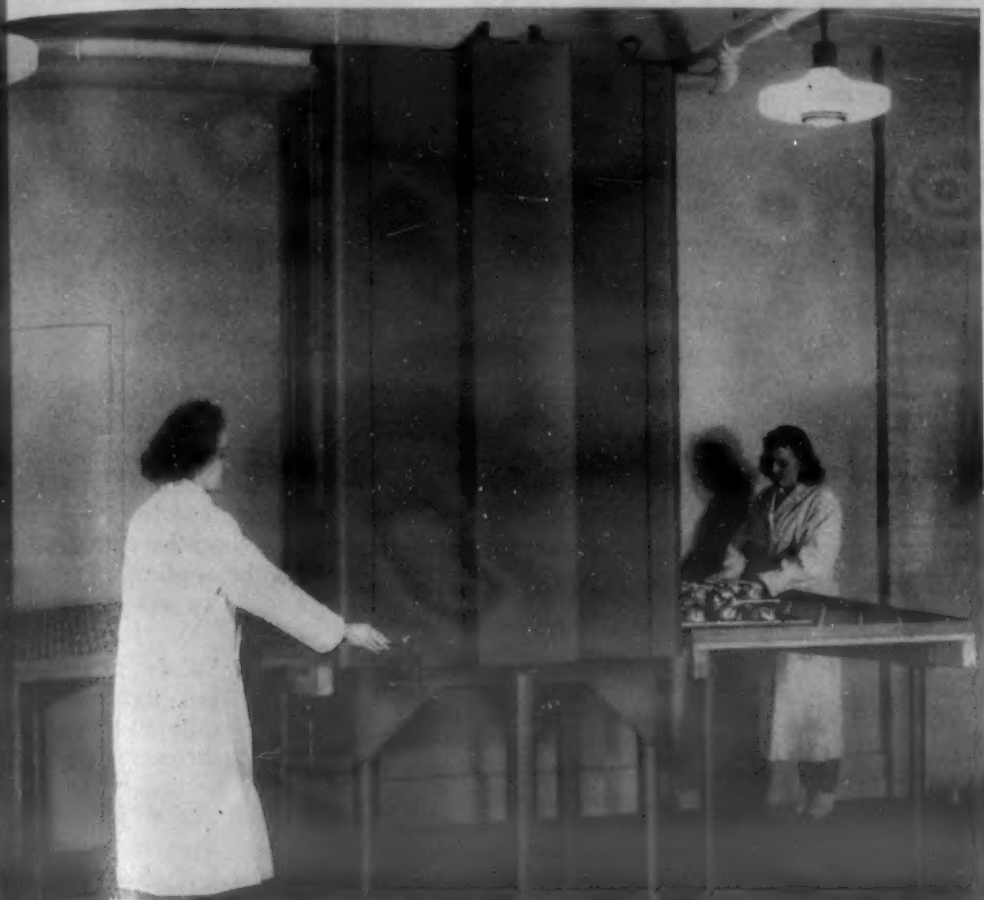
Direct visual X-ray examination of castings with the aid of a fluoroscopic screen is not as widely used in this country as examination by photography ("radiography"). Although of limited value, fluoroscopic examination, used in conjunction with radiography, reduces costs. In a laboratory where 400 to 1000 castings are examined daily as much as $15 to $40 per day in film costs is saved by fluoroscopic elimination of castings containing major flaws, before radiographic routine is started. The fluoroscopic accessories for this laboratory did not cost more than $200.

Limited sensitivity and contrast possible of attainment compared with radiography limit the use of fluoroscopy in examining casting specimens to those of light alloys of aluminum and magnesium. Although not acceptable for inspection of highly stressed aircraft castings, for low or non-stressed parts and for many industrial castings where the primary requirement is absence of gross defects, the screening method is satisfactory. It is widely used for this purpose in British practice.

### Screening Equipment

The apparatus and methods evolved in

**SEMI-AUTOMATIC UNIT** provides rapid, accurate production-line x-ray examination of castings or metal assemblies. Convenient control station operates x-ray unit.



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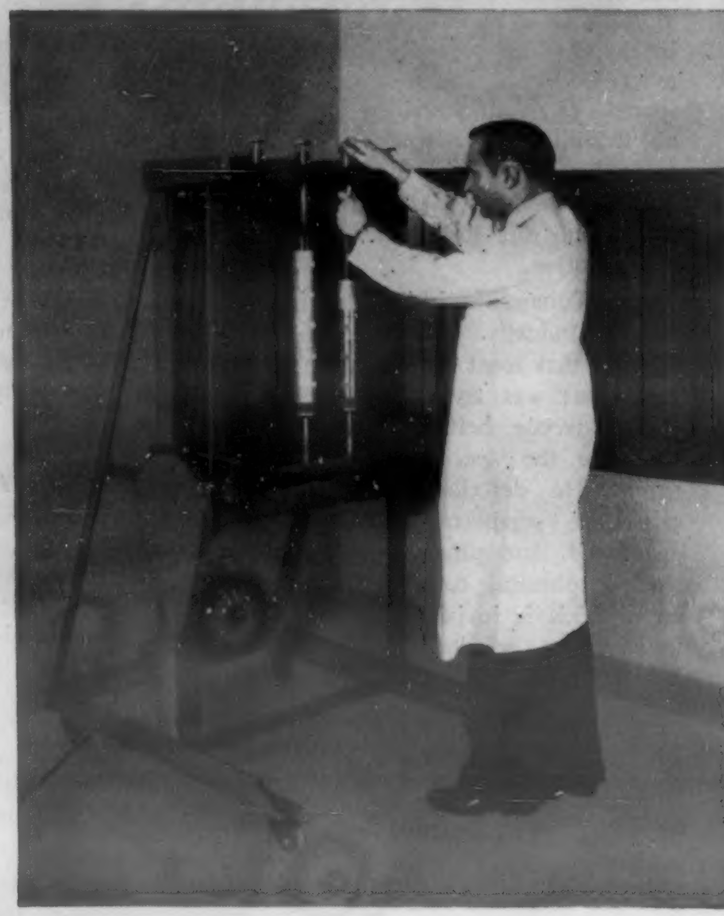

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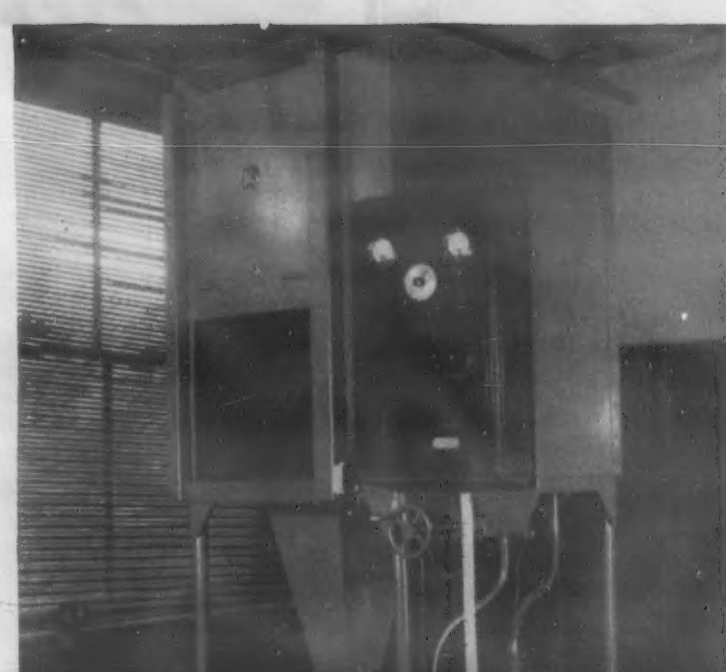

**NEW,** compact, self-contained G-E Industrial Photo-Radiograph Unit inspects small castings for major defects at one-eighth the cost of direct x-ray inspection.

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England for screening practice have been influenced by the inspection instructions of the British Air Ministry which stipulate that the casting must be in continuous movement in the X-ray beam by means of tongs or a remote handling mechanism. In the opinion of the author this has led to (a) Over-compression into minimum space. (b) Self-contained designs leaving no flexibility or adaptability of the tube for radiography. (c) Slowness of manipulation methods. (d) Decreased efficiency in viewing due to fatigue caused by long manipulation.

E. J. Tunnicliffe, in "X-Rays in the Light Metals Industry" (British) Sept. 1942, claimed that most "home made" screening equipment was unsafe and inefficient and that conveyor belts and turntables used to move the specimens were unsatisfactory. He described a special machine called the "perspectrosphere" which he had developed that provides a remotely controlled spherical container for the specimen. This is invisible when the machine is in action, so does not cause masking. It rotates the specimen through 360 deg. through every plane and reduces fatigue as the specimen is not handled during inspection.

The writer of this article feels that Mr. Tunnecliffe's impeachment of "home made" equipment is unwarranted and that conveyor belts and turntables may be used effectively.

#### One Canadian Set-Up

In a Canadian foundry a fluorescent screen arrangement was added to the existing radiographic set-up. The screen housing is of wood with an 8 in. x 10 in. fluoroscopic screen. The screen belt is of 3 ply interwoven cotton, one ft. in width, while the rolls are of wood 10 in. in diam. run on ball bearings. A similar belt returns satisfactory castings. Faulty ones are pushed off with a rake controlled by the viewer. In the viewing control booth a hand wheel is attached to the axis of the roller on the discharge end of the screening belt. This is manipulated by the viewer to move the screening belt carrying the castings back and forth over the screen.

#### Sensitivity of Fluoroscope Examination

The sensitivity attainable averages 10 per cent. Constant practice in conjunction with the most favorable section thickness and ideal physical viewing conditions frequently brings it down to 5 per cent or less. Complete darkness is the greatest essential. The minimum for potential and current is about 140 kv. at 10 milliamperes. The optimum depends upon the individual viewer. Target-screen distance should be fairly small. Good results are obtainable from 18 to 30 in.

Defects most effectively seen on the screen are blow-holes, heavy metal inclusions and fairly heavy shrinkage defects. Screening is still ineffective for detection of minute gas pockets of less than 10 per cent of the section thickness and for fine shrinkage, internal hot tears, pinhole porosity and small sand or slag inclusions. It must therefore be used circumspectly and supplemented by radiograph checks.

—A. E. Cartwright, *American Foundrymen's Assoc., Preprint No. 43-19,* April 1943.

## The Spectrograph in the Steel Mill

*Condensed from a paper for The Iron and Steel Institute (Gt. Britain)*

Developments in the technique and application of spectrographic methods to quantitative analysis have been rapid in recent years. In regard to steel, F. G. Barker in 1939 (See METALS AND ALLOYS, Vol. 10, Aug. 1939, p. 491) discussed and laid down a detailed procedure for the application of the spectrograph to low-alloy materials. The present authors have studied in considerable detail the application of such a method to routine steelworks analysis.

Errors in spectrographic analysis are often considerably greater than those of the alternative chemical procedure and possible advantages in speed or economy can only be exploited where the magnitude of the errors, coupled with the wideness of the melting specifications, makes their toleration possible. To explore the possibilities the whole technique has been studied and various precautions and mod-

ifications have been introduced to minimize maximum errors without rendering the process impracticable or uneconomic.

The highest accuracy is to be expected where large numbers of casts are melted to a single specification, permitting concentration on a relatively narrow range of composition. In the authors' work this has been possible in the case of two high-alloy steels (12.5 Ni, 5 Cr, 5.5 Mn, 0.3% V; 14.5 Cr, 12.5 Ni, 3 W, 1.2% Si), and many thousands of casts have been successfully analyzed.

In addition, working details and typical results are given for the case of mixed batches of low-alloy steels. Although the lower accuracy attainable under such conditions, together with, in general, much narrower melting specifications, has so far prevented the successful large-scale application of this procedure by the authors to the routine works analysis of such low-alloy steels, considerable use has been made of the method in special cases.

Moreover, conditions in individual works vary, and where they are such as to permit the concentration of a more limited range of compositions on individual plates, higher accuracy and more successful applications are to be expected for these materials also.

#### Equipment and Principles

There are now various types of spectrographic apparatus on the market, including prism and grating spectrographs and recording and non-recording photometers.

For the work here described the authors have used essentially the same apparatus as that described in Barker's paper, consisting of Hilger large quartz spectrographs, Hilger non-recording photo-electric microphotometers, and the Judd Lewis comparator for the general qualitative comparison and examination of plates and preliminary work on line selection.

The general principles of spectrographic technique are now widely understood. Briefly, in the work here described, the specimen to be analyzed is used as one electrode, and a pointed carbon rod as the other. Passage of current from a 15,000-v. transformer across the gap between the electrodes vaporizes some of the steel and causes it to emit light of wave-lengths which are characteristic of the particular elements present.

The spectrograph splits up the composite light so emitted, giving a series of lines on a photographic plate, each line corresponding in position to light of a given wave-length and in blackness to the intensity of the light of that particular wave-length. The intensity of light of any selected wave-lengths can then be determined from the density of the corresponding line on the photographic plate, this density being measured by the photo-electric photometer. The results of such determinations are then related to the composition of the sample by means of curves based on the response of "standard" sample of known chemical analysis under similar conditions.

In practice various corrections are required, and a first correction for fluctuation in the general density of the spectra is made by plotting, not the simple intensity or log intensity against composition, but the log ratio of the photometer readings for the selected line of the element in question and a suitable comparison iron line, the iron line being used as a measure of the general relative density of the spectrum under consideration.

#### Errors

With careful work, and without further correction, it will usually be found that most of the errors are within ± 5 per cent of the amount of the element present, but occasional errors up to as much as ± 10 per cent will occur. Thus, for example, occasional errors of as much as ± 0.25 per cent on 2.5-3.5 per cent nickel are found. Errors of this magnitude are, of course, too high for analytical work with steel melted to narrow specification limits if the melting tolerance is not to be entirely absorbed by the spectrographic error.

In passing, it may be pointed out that the matter of most practical interest is not the carefully computed mean error for the process but the magnitude and frequency of the maximum errors likely to be encountered. For successful application to routine analysis it is evident that every endeavor must be made to reduce these maximum errors and to confine the use of the method to fields where the residual liability to error can be tolerated.

—H. T. Shirley & E. Elliott, *Iron & Steel Inst.*, Adv. Copy, Jan. 1943, 25 pp.

# books

## FOR METALLURGICAL ENGINEERS

### Oxides of 32 Metals

THE TOTAL AND FREE ENERGIES OF FORMATION OF THE OXIDES OF THIRTY-TWO METALS. *By M. de K. Thomson. Published by The Electrochemical Society, New York, 1942. Paper, 6 x 9 in., 89 pages. Price $1.00.*

This pamphlet collects recalculated data from the literature pertaining to the heat and free energy of metal oxides, based on reduction equilibria, the third law of thermodynamics, and the electromotive force of reversible cells.

This booklet should prove of great convenience to those occasionally using thermodynamic calculations relating to these substances, and where unfortunately situated with respect to library facilities, or who do not have the time or inclination to refer to original sources. Prof. Thomson has generously shouldered the drudgery inherent in a comprehensive review of this sort, that surely, at the nominal price must have been a labor of love. It is to be hoped that the circulation of his work will be enough to justify the pains that he has taken in it.

The reviewer would like to endorse this work as authoritative, but is restrained because he feels that the author's method of a weightless formal average of results of various investigators is too great a sacrifice to attempted complete impartiality. One of the very practical uses of thermodynamic methods resides in the facility provided for exact correlation and corroboration of experimental data that may be of direct technical importance. The power of this method reaches far beyond the mere justification for rejection of obviously discordant results. Thus, the data contained in this pamphlet have been treated in an assimilative rather than critical manner, that turns out unfortunately in some instances.

For example, four values of the free energy of formation of zinc oxide at 25 deg. are averaged with equal weight, one each from equilibria (3 sets of reduction equilibria included), solubility, emf., and the third law of thermodynamics, but the latter an erroneous figure differing by about 1500 calories from the mean, and by about 2000 calories from the most concordant figures. It is highly improbable that a cumulative error of 5 or more entropy units could exist for the substances involved, nor is there now an uncertainty of 2000 calories in the heat of reaction.

This booklet is not indexed, but an appendix gives page and "Equation Number" references to the heat and free energy of formation quantities that have been calculated. It would have added little to the cost if specific figures, chosen at some suitable reference temperature, had been tabulated here, and convenience in casual use would have been facilitated greatly.

In spite of this work being somewhat disappointing in content as a critical review, justified both by the potentialities of the method and the experience of the author, it will save the user of such figures many times its cost.

—C. G. MAIER

### Peace and World Minerals

WORLD MINERALS AND WORLD PEACE. *By C. K. Leith, J. W. Furness and C. Lewis. Published by The Brookings Institution, Washington, D. C., 1943. Cloth, 6¼ x 9¼ in., 253 pages. Price $2.50.*

The statistics of distribution production and use of minerals are set forth in such manner as to give a bird's-eye view of the world situation. This makes it a handy reference volume when seeking data that otherwise have to be assembled from scattered original sources.

Political control, monopolies and cartels are discussed as are the efforts of various nations to achieve mineral self-sufficiency.

From the facts and figures it is deduced that every nation is a have-not in respect to at least a few necessary minerals, and in peace time, and to maintain peace, swapping, so that everybody gets what he needs, is in order. However, peace time access offers opportunity for stock piling for war purposes, so this leads to the double barrelled conclusion that the United States and the other nations that will have to exercise the police function of maintaining peace must build and keep up adequate stock piles, to have the striking force necessary in a show-down, and that as a necessary corollary, the Axis nations will have to be prevented from applying their peacetime intake of minerals to the manufacture of munitions.

Just how the control and inspection of imports into Axis nations and the allocation of those imports to permitted peaceful uses and their restriction from nefarious uses can be carried out is set up as one of the most important matters to be tackled when peace negotiations are carried out.

The book expands the thoughts that Dr. Leith has expressed in previous lectures and papers, but doesn't have the clarity and punch of these shorter statements with Leith as sole author. It would have been better to have reprinted one of Leith's previous high-spot summaries, as the introductory chapter, for the present book is a drier elaboration and documentation of Leith's general argument.

The "pie" charts showing production and the maps showing trade routes and distribution are illuminating.

—H. W. GILLETT

### Metal Handbook

QUIN'S METAL HANDBOOK AND STATISTICS—1942. *Published by Metal Information Bureau, Ltd., Oxon, England, 1942. Cloth, 4½ x 6½ in., 379 pages. Price 10s.*

The 29th annual edition of this pocket-sized international statistical reference or handbook on metals and minerals contains a good deal of new and interesting information and data. Estimated figures of world production of some of the principal non-ferrous metals in 1941 are pointed to as an exclusive feature.

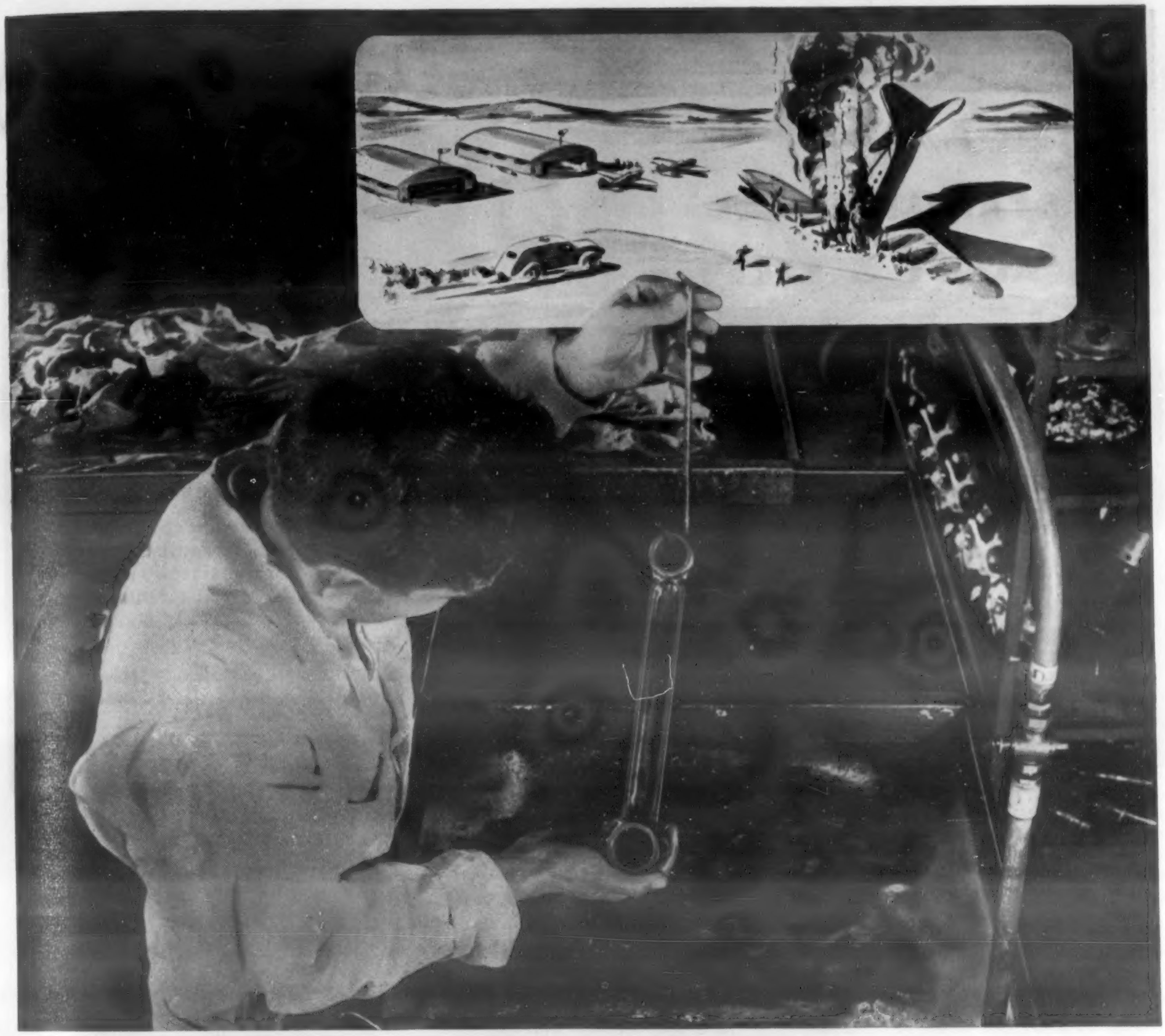
The book has been revised and enlarged and many tables have been rearranged. An interesting new feature is the tables of the physical constants of metals and details of the weights and gage size of semi-finished metal products.

Another new feature is information on the properties and uses of the minor metals which are of growing importance in modern metallurgy.

Because of the expanding use of the light metals in aircraft and other industrial uses, some comprehensive notes on aluminum and magnesium base alloys, their manufacture, properties and uses as well as the best way to machine them, have been included.

—EDWIN F. CONE

*(Continued on page 170)*



## BOOK REVIEWS

(Continued from page 168)

### Metallographic Laboratory Practice

THE PRINCIPLES OF METALLOGRAPHIC LABORATORY PRACTICE—2D EDITION. By *George L. Kehl. Published by McGraw-Hill Book Co., Inc., New York, 1943. Fabrikoid, 6¼ x 9¼ in., 453 pages. Price $4.00.*

This is the second edition of a book published four years earlier. The second edition follows the same scheme as the first but has been expanded 94 pages, a considerable part of which is by adding new tables or more comprehensive tables in the Appendix which now contains 58 pages. The book has been materially improved by the addition of new illustrations, particularly those which show incorrect and correct laboratory techniques.

The objective of the book is stated in the author's preface—"bridging the gap between theoretical physical metallurgy and its practical application in the laboratory." Thus, while this book is neither a treatise on physical metallurgy nor the ordinary laboratory manual, most laboratory workers should be able to improve their practice and the results obtained by a diligent use of Kehl's book.

The scope of the work is indicated by chapter headings as follows: 1. Preparation of Specimens for Microscopic Examination; 2. Etching of Specimens for Microscopic Examination; 3. Metallurgical Microscopes and Photomicrography; 4. The Principles of Photography; 5. Macroscopic Examination of Metals; 6. Hardness Testing; 7. Special Metallurgical Tests; 8. The Principles of Pyrometry and Pyrometric Practice, and 9. Thermal Analysis.

The chapter dealing with the preparation of specimens presents a sound discussion of the principles involved and a number of special techniques which may be used. There is sufficient discussion of individual metals and of special alloys so that it should be possible to apply the techniques described to most of the materials encountered in the laboratory. Author and publisher deserve credit for getting better than the usual photomicrographs and photomacrographs. The author has relied largely on hardness testing as a means of correlating microstructures with engineering properties. This is obviously the most convenient laboratory practice but does not make possible a complete correlation between microstructures and some of the properties which are of interest in the practical application of metals and alloys.

The data contained in the 51 tables in the Appendix are generally available in some other sources, but it should be a decided convenience to the laboratory worker to have all of these tables collected and conveniently arranged in one volume.

Finally, the index of 24 pages has been carefully arranged so that special subject matter can be found readily. Extensive use of this book should contribute to improved practice in metallographic laboratories.

—OSCAR E. HARDER

### Other New Books

1943 SAE HANDBOOK—33d EDITION. *Published by the Society of Automotive Engineers, New York, 1943. Cloth, 5¾ x 8¾ in., 810 pages. Price $5.00.* This edition features new, revised, and emergency materials specifications designed to conserve critical materials and expedite procurement. Extensive revisions and additions appear especially in the section on non-ferrous metals, which includes emergency alternate specifications developed in cooperation with the WPB. The NE steel compositions, Army-Navy hardness-tensile strength tables, and ASTM arithmetical form for plotting hardenability curves, provide additional convenient reference data. The Aeronautical Section contains extensive additions to and revisions of SAE Aeronautical Materials Specifications, Aeronautical Standards, Aeronautical Recommended Practices, and Aeronautical Information Reports. To expedite action in the war emergency, a section on "War Emergency Recommended Practices" has been added to Standards Committee Regulations in the introduction of the Handbook.

A. S. T. M. STANDARDS ON SOAPS AND OTHER DETERGENTS. *Prepared by A. S. T. M. Committee D-12. Published by the American Society for Testing Materials, Philadelphia, 1942. Paper, 6 x 9 in., 128 pages. Price $1.35.* This compilation brings together all of the A. S. T. M. standards and tentative standards pertaining to soaps and other detergents in pamphlet form. There are 15 specifications and 2 methods of analysis for soaps and soap products included, as well as also 7 specifications and 4 methods of analysis covering special detergents. There will also be found proposed methods of chemical analysis of metal cleaning compositions and an annotated bibliography of aluminum cleaning. Emergency alternate provisions for some of the specifications have been included.

# METALLURGICAL ENGINEERING news

*Equipment • Finishes • Materials • Methods • Processes • Products*
*Alloys • Applications • Designs • People • Plants • Societies*

## Foolproof Carbide Cutting Tool Grinding

A new principle that may make unnecessary highly skilled labor on carbide cutting tool grinding has been developed cooperatively by *Carboloy Co., Inc.,* Detroit, and the *Edison* ("Hotpoint") *General Electric Co.,* Chicago.

Heretofore, skill has been needed due to the following conditions: Enough pressure must be applied to the tool on the grinding wheel, yet not enough to overheat and cause thermal-cracking. The tool must be kept moving to avoid localized overheating, to distribute wear on the wheels and to get good finish. They must be ground toward rather than away from the edge, to prevent breaking out of small particles at the edge. Angles must be held closer than normal for high speed steel tools.

A single purpose machine was developed to grind the top faces of standard carbide tools, which is accomplished in from 8 to 30 sec. per tool, averaging 25 sec., an output 6 times that possible with a pedestal grinder. In addition to rotating, the grinding wheel also oscillates while the tool is held stationary at the correct angle. The oscillation, in the plane of the wheel, also contributes to the speed with which tools can be ground.

Air pressure is used to hold the tool against the wheel, constant and controlled, insuring maximum grinding speed consistent with quality of finish, wheel life, heat generated, etc. Pressure is low to remove jagged edges, automatically increasing to the pre-set amount, and held until finish ground. A simple dial control sets the time cycle.

The automatic machines are equipped with metal-bonded diamond-impregnated wheels, making for vastly increased wheel life. The principles have already been applied to high-speed steel tools.

The young lady, in the photo, is doing what is usually one of the toughest jobs — grinding the top face. But now it is one of the simplest, and is being done here at the rate of 80 to 100 per hr.

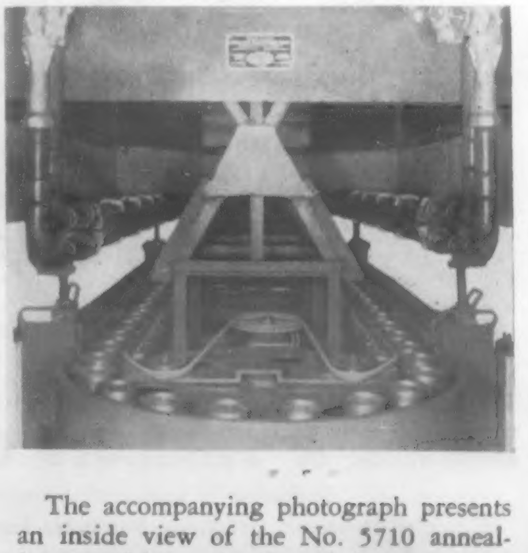
## Continuous Annealing Machine for Steel Cartridge Cases

A flame-type mouth and body annealing machine, continuous type, for steel cartridge cases has been developed by the *Morrison Engineering Co.,* Cleveland. To cover the proper range of sizes, three models are offered. The 3740 will handle 37 and 40 mm. cases; 5710 will accommodate 57, 75 and 105 mm. cases; while 390 takes care of the 90 mm. and 3 in. anti-aircraft cases.

Production varies from 400 to 2000 cases per hr., depending on general production line speed. Burner equipment is of the blast line type, with zero governors and proportional mixers for each burner. Manometers provide that when a satisfactory adjustment of the burners is attained and the pressure mixture observed on the manometer, this same burner setting can be duplicated.

By operating at high mixture pressures and rotating the work from 60 to 100 r.p.m. in front of the burners, extremely fast heating is attained. There is no cooling due to rotating because of the speed. Burners provide a holding zone in addition to the heating zone.

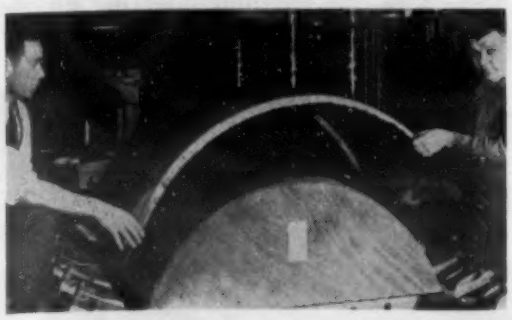
When close control of temperature in the lower part of the cartridge case is necessary to prevent over-annealing, a cold blast blower may be installed. Gas economy is high and repairs negligible.



The accompanying photograph presents an inside view of the No. 5710 annealing machine, showing belt-type rotating mechanism and adjustable burners.

## Phenolic Casting Resins for Dies

Phenolic casting resins have been used effectively for the production of a stretch-press cowling die at *Fairchild Aviation*. The accompanying photograph shows this



die, over 4 ft. across and 2 ft. thick, made in less than 24 hrs. It was delivered two days sooner and at more than 50 per cent saving in costs than another type of material, states *Durez Plastics & Chemicals, Inc.*, No. Tonawanda, N. Y.

Two hundred pounds of resin were needed to form a shell over 2 in. thick over the core. The mold, resin and core were cured in an oven for 3½ hrs. at a constant temperature of 130 deg. F.

● Substitution of hot-finished for cold-drawn seamless steel tubing as a means of increasing tubing output is being advocated by the *Seamless Steel Tube Institute*, Gulf Building, Pittsburgh. This recommendation covers the larger sizes, with heavier walls, which are so often machined, usually that of 3 in. O.D., or larger. Such substitution will eliminate the time lost in annealing and heat treating.

## Low-High Temperature Test Chambers

A low- and high-temperature test chamber, with range of —67 deg. F. to plus 160 deg. F., has been brought out by *American Coils Co.*, 25 Lexington St., Newark, N. J. It has a new attachment for humidity control, the range being ambient to 140 deg. F., ambient to 90 per cent relative.

Model RTC-1H embodies, as an integral part, equipment for mechanical refrigeration and electric heating, which give a very fast rate of temperature and humidity change. Included are a 2-stage Freon condensing unit and special refrigeration accessory developments, which result in flexible operation at various loads and temperatures.

The equipment is dependable for tests on delicate mechanisms and precision equipment.

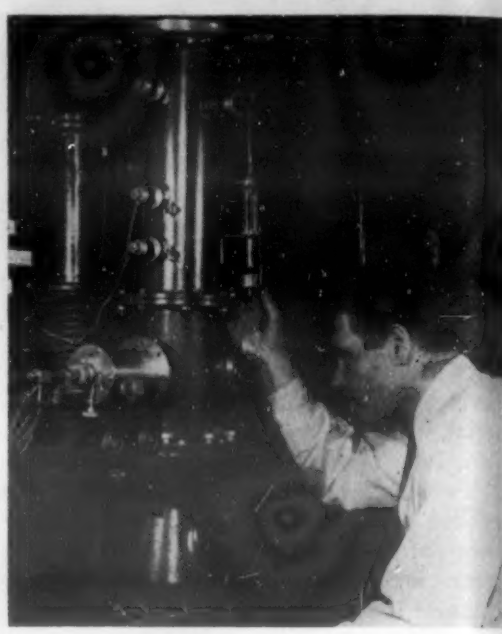
● A new all-position electrode, designed especially for use with a.c. transformer welding machines, has been put out by *Harnischfeger Corp.*, 4400 W. National Ave., Milwaukee. Suited for all mild steel applications, it is made in usual sizes of 1/8, 3/32, 3/16, 1/4 and 5/16 in., and 14 and 18 in. lengths, packed in standard 50-lb. containers.

## Electronics Studies Corrosion Coatings

Coatings that form on steel, aluminum and copper from corrosive influences are being studied at *Westinghouse Research Laboratories*, E. Pittsburgh, Pa., by Dr. Earl A. Gulbransen, who shoots billions of electronic bullets a second with a vacuum tube "machine gun," thereby allowing him to ascertain their atomic structures.

Through his work with his electronic diffraction camera, it will be possible to provide better metals for specific jobs where corrosion resistance is needed. Thus, small amounts of alloy metal can alter the nature of the coating formed on a piston ring, cylinder wall or motor bearing. Iron, for example, acquires a coating of rough iron oxide when exposed to air, but when 1 per cent of chromium is added, the coating formed is chromium oxide, a thin protective layer that hinders oxidation. This work may also lead to better tin plate, where the tin will cling more tightly to the steel, or to cheaper stainless steel.

Electrons are shot through the 3-ft. long vacuum tube and bounced off a highly polished button of aluminum or steel on which an oxide coating is being built. The electrons ricochet off the faces of the block-like molecules that form the coating and continue downward at an angle to strike a strip of photographic film. The electrons trace a pattern of black and white semi-circles that appear on the developed film, formed by the electrons bouncing off the



different faces of the molecules in the coating. The resulting picture reveals the molecular structure of the coating.

The electronic bullets are forced out of a small aluminum rod at the vacuum tube's top by 50,000 volts. When the voltage is applied to the rod, a pin point area on the rod's end gives off free electrons that speed through the tube at 4,500,000 miles per hr. The buttons, used as targets, are inserted, 6 at a time, in a magazine that fits into the side of the vacuum tube. By revolving the magazine, any button can be brought into the field of electronic fire. Electrical resistance wires in the magazine heat the buttons to accelerate coatings formations. Measured amounts of hydrogen and oxygen can be admitted into the tube to speed the coating's growth.

In the accompanying photograph, Dr. Gulbransen is adjusting a valve that regulates the gas pressure in the tube where the electrons are being formed.



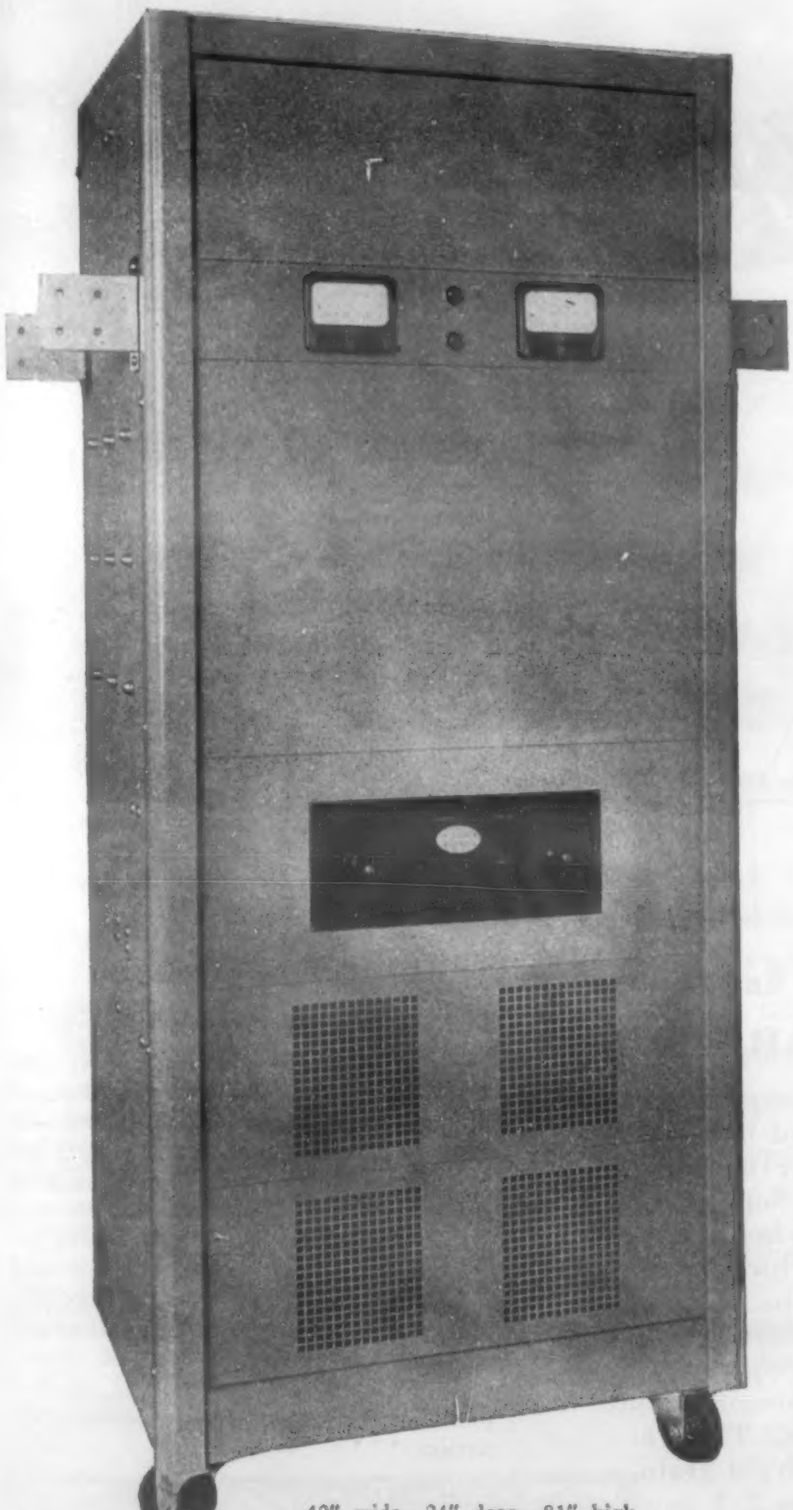
## Bandsaw with Gravity Feed

A metal-cutting bandsaw with exclusive new gravity feed principle is announced by *Universal Vise & Tool Co.*, Parma, Mich. The saw blade feeds into the work through the movement of the balanced blade wheel frame on an inclined track. Blade pressure is automatically regulated by texture and degree of hardness of metal being cut.

It requires no attention from the operator, and eliminates blade breakage due to incorrect pressure. The saw is adaptable for cut off, trim and contour work. A swivel block for holding work is instantly removable for contour jobs or long straight cuts.

# GREEN SELECTRO-PLATER

**COMPLETE IN ONE CABINET WITH METERS AND CONTROLS BUILT IN**



42" wide—24" deep—81" high.
Output capacity 6 volts—4,000 amperes.

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12 Volts—600 - 1200 - 1800 - 2400 amperes

16 Volts—300 - 600 - 900 - 1200 - 1500 - 1800 amperes

24 Volts—300 - 600 - 900 - 1200 amperes

48 Volts—300 - 600 amperes

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*Builders of SELECTRO-PLATERS and all types of rectifier equipments.*

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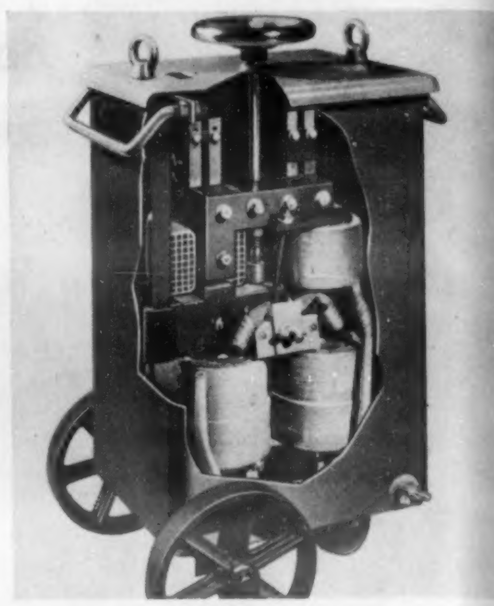
## New A.C. Welder

Described as the welder with the ideal operating curves, the new a.c. Ampac "200," made by *Allis-Chalmers Mfg. Co.*, Milwaukee, automatically gives the operator correct voltage for the continuous range of currents available, rather than using an almost constant voltage at all current settings. This adjustment not only makes welding easy at low currents because of the high striking voltage, but saves power when welding at high currents because the voltage is low.

Other features are the new integrated reactor-transformer construction, which provides the high, yet safe voltage for easy welding at low currents; active duty from every line of flux, assured by reactor coils, which surround the variable air gap; and simplified construction using fewer working parts, cutting down maintenance to routine lubrication twice a year. With no arc magnetism to cause the arc to wander and weave, welding becomes easier, especially for inexperienced welders.

The Ampac "200" handles rods 1/16 to 1/4 in., for thin sheets or heavier



plates. Most d.c. rods as well as all a.c. rods can be used because of the welder's unusual arc stability.

● New car wheel assemblies are ideal for core oven cars, mold drying cars, furnace bottom cars and other handling units, as announced by *Phillips Mine & Mill Supply Co.*, 2240 Jane St., Pittsburgh. They are suitable for replacement or originals, are available in 12 to 18 in. diameters, and feature Timken roller bearings with grease fittings, or bronze Metalline oilless bushings for high-temperature applications.

## New Series of Metal Cutting Oils

A series of metal cutting oils that are definite improvements over existing products are claimed by *National Oil Products Co.*, Harrison, N. J. They impart increased oiliness, copious wetting and cooling ability, and resistance to rust and corrosion, oxidation and rancidity.

They are known as Vegicut A and Vegicut B, low and medium viscosity oils; Vegisol, an emulsifying cutting oil readily soluble in a wide range of waters; and Vegisulph, a sulphurized product providing maximum anti-welding protection.

● Manganese steel is used for parts of an airplane testing turntable, not only because of its toughness, resistance to stress and moderate cost, but also because it is non-magnetic. All steel becomes non-magnetic above certain temperatures, but standard manganese steel holds the same non-magnetic properties when cold that it had at the quenching temperature of 1850 deg. F., it is pointed out by the *American Manganese Steel Div., Am. Brake Shoe Co.*, Chicago Heights, Ill.

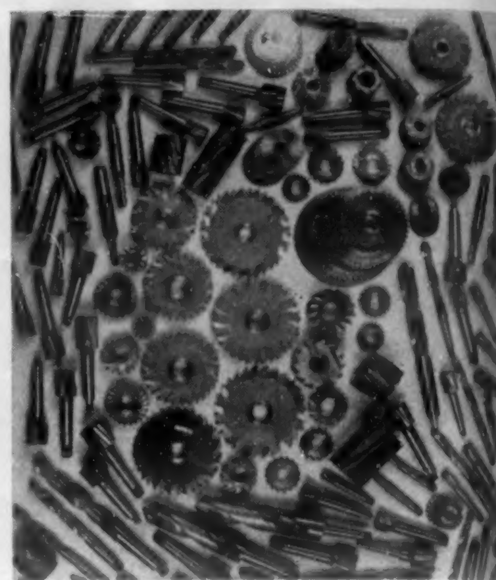
## Workers Loan Own Tools to G. E.

When production requirements created an unexpected heavy demand for drills, taps, reamers, saws, and miscellaneous tools at *General Electric's* Pittsfield Works recently, maintenance department workmen loaned the company a total of 992 small tools from their own chests, augmenting a salvage and reclamation program that averted an emergency.

The personal tool chest collection was in response to an explanation of the situation by the maintenance department foremen, who promised that the tools turned in would be replaced by the company as new tools were obtained. Among the tools contributed were straight and taper shank drills, taps and reamers, with a total value of $1198, and they were all fit for immediate use.

Meanwhile, through the plant's salvage and reclamation program, 1700 lbs. of high-speed steel tools were recut at a cost of $2500 into new tools, with a value of approximately $4500. Tools that could not be reclaimed were sold to toolmakers after being spark-tested and classified according to type of steel.

In the accompanying photo are representative items loaned to the company, mostly milling cutters and drills.





● A comparatively new product is apparently proving successful in preventing or alleviating occupational dermatoses, which are brought on by chemical irritation, chronic exposure to abrasive work with cutting oils, reagents, acids, etc. This product is Tarbonis cream, made by the *Tarbonis Co.*, 1220 Huron Rd., Cleveland. It is a modified tar product based on a formula developed in a world-famous medical institution.

## Adapter for Hole Punching Units

A hole punching unit model, with built-in adjustable adapter that has practically universal adjustment from left to right and front to back, is the "CA," made by *Wales-Strippit Corp.*, No. Tonawanda, N. Y. An adjustment up to 1½ in. front to back for "off center" or staggered hole patterns, when used in set-ups on press brakes, is provided.

By designing the punch and die into the same independent holder, it is possible, with a master pattern as guide, to locate hole punching units in exact position by sliding the units along the rail. Where holes are off a straight line pattern, the units can be moved front to back on the new adapter and locked in position.

The same group of units can be reset or removed to provide unlimited center-to-center distances.

● Another use has been found for Koroseal, the plasticized polyvinyl chloride, developed by the *B. F. Goodrich Co.*, Akron, Ohio. Thus, a New York company, who chrome hardens surfaces of engine cylinders, gun barrels, etc., uses Koroseal sheet as an insulator for use in plating these.

## New Magnet Steel Cores

A new line of "C" Hipersil steel cores for radio transformers, chokers, relays, etc. is announced by *Westinghouse Electric & Mfg. Co.*, East Pittsburgh, Pa. They combine one-third more flux-carrying capacity with the same size and weight. They simplify assembly and replacement, since only 2 or 4 pieces are involved.

Construction consists of winding the strip continuously on a mandrel, then annealing it at high-temperature and vacuum impregnating with a plastic. Next, it is cut into two segments, the ends of which are machined and worked to produce coinciding surfaces when reassembled.

A check test is made for fidelity of performance. Cores are assembled on coils by metal bands tightened to insure correct tension. The butt joint eliminates cross fluxes or masking effect, and does not increase core loss. Each joint is equal magnetically to 0.0005 air gap.

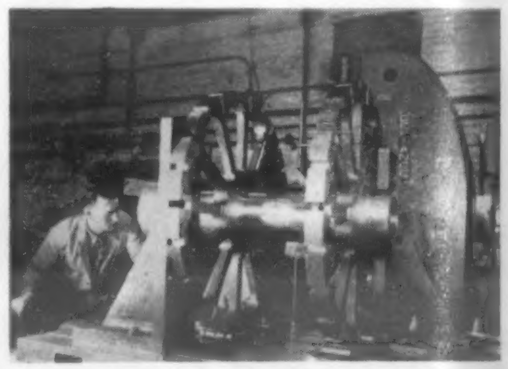
For frequencies up to 400 cycles "C," Hipersil steel cores of nominal gage are used; for higher frequencies, a core using thinner steel is used; for very high frequencies, a still thinner gage.



● A new type of lignin plastic, which can be made from farm wastes and used as a replacement for metals, was announced recently by Secretary of Agriculture, Claude R. Wickard. This thermosetting plastic can be made from corn stalks, wheat straw, flax shives and other fibrous materials. Only one-half the phenol-formaldehyde resin usually used is needed. Physical properties are similar to those that use the higher percentage of phenol-formaldehyde. Already a military use has been found practical.

## Largest Honing Tool Being Machined

A honing tool, 41½ in. in diam., is shown in the accompanying photograph being machined on a boring mill of the



*Defiance Machine Works, Inc.*, Defiance, Ohio, at the plant of the *Micromatic Hone Co.*, Detroit.

This honing tool is said to be the largest ever made in the world.

## Skin-Drier for Green Sand Molds

For skin-drying green sand molds in foundries, the "Radicon" has been developed by *Infra-Red Engineers, Inc.*, 812 Huron Rd., Cleveland. It weighs 180 lbs., and can be carried anywhere in the foundry by two men. It will handle molds of any volume up to 46 in. long, 36 in. wide and 36 in. high. Among the advantages claimed are: it eliminates or reduces blowholes, reduces time required (average, 90 min. with penetration of 1½ in.) reduces labor, requires less mold drying floor space, and reduces cost.

To operate, one places the Radicon over the mold, or molds, and lowers the heater assembly to within 2 in. of the flask or cope. Then the heater assembly switches, which control the sections covering the molds, are turned on. Within 90 sec. vapors will arise, indicating that drying has begun.

# Nº 170 TYPE DEOXIDINE

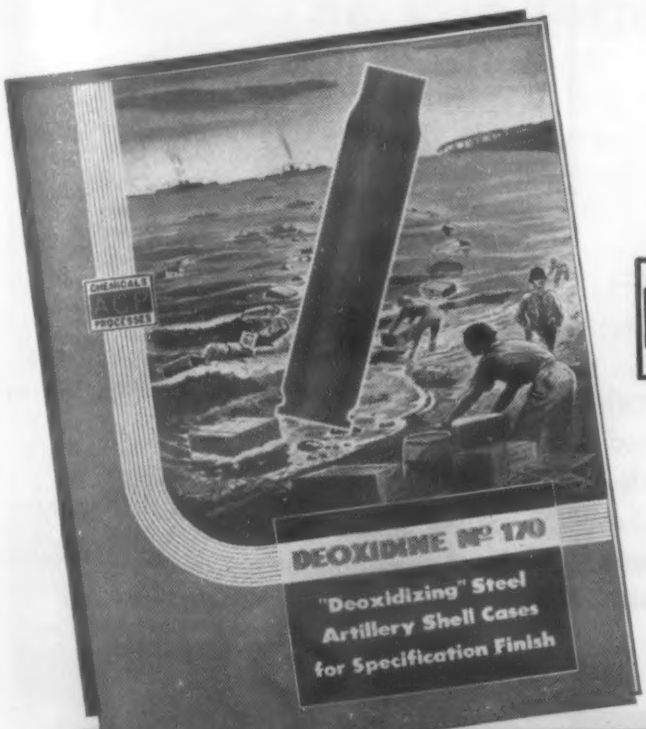
## For GREATER EFFICIENCY

### in Preparing Steel and Aluminum Ordnance Parts For Varnish and Paint Finishes...

DEOXIDINE #170, admirably suited to the processing of steel shell cases, is but one of a number of grades of ACP acid cleaners. The immersion process in which it is used is adaptable to the cleaning of many other ordnance or marine parts. Other grades of DEOXIDINE are available for brush or spray processes where these are indicated for expediting production.

DEOXIDINE #170 is a chemical that removes light oil, annealing scale and eradicates rust and rusters, producing a clean, minutely-etched, paint-receptive surface. The rusters, even though invisible, are destroyed, eliminating the possibility of defects developing beneath the protective finish. DEOXIDINE does not produce a coating on the cleaned surface which on shell cases, for example, might crack in crimping and in obturation and ruin the protection of the final finish.

DEOXIDINE meets U.S. Ordnance Department requirements for its efficiency in removing rust and neutralizing rust producers before protective finishes are applied.

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## Instrument for Identifying Ferrous Alloys

An "identometer" is an electrical instrument for identifying instantly and accurately any ferrous alloy, as the maker claims, by the use of reference specimens. A known sample is affixed to one clamp and the unknown to the other. When the two are brought into contact, the lighted indicator registers on a scale whether the two are of the same chemical analysis.

It is possible to classify unknown pieces as to heats (identical analysis); grades (similar analysis); types (dissimilar analysis); heat treatments (identical analysis with dissimilar structure); composite types (two and three plys, clad metals, sheer knife, etc.). The identometer can be used to identify metals in any stage of their working, from the ingot onward, if cooled to room temperature.

It is manufactured by *American Tubular Elevator Co., Instruments Div.,* Neville Island, Pittsburgh.

● For work needing ultra high-speed cutting, a new saw model has been developed by the *Johnson Mfg. Corp.,* Albion, Mich. The pump is a non-clogging, piston type, driven by a noiseless cam. Power is taken from the present drive gear, eliminating necessity of a separate motor. The speed of the machine regulates the pump's speed; the flow of coolant is related to blade speed. If dry cutting is desired, the pump can be disconnected readily.

## Copper Mesh and Rubber for Gaskets

Copper mesh coated with synthetic rubber and used as gaskets in many airplane engines is hailed in many quarters as an outstanding development. The rubber-sheathed mesh, less than 0.015 in. thick, results in longer life and decreased oil consumption, it is claimed by *Detroit Gasket & Mfg. Co.,* Detroit, who originated the idea, and by *Goodyear Tire & Rubber Co.,* Akron, Ohio, who produce them.

They replace the type that used asbestos, fibre, or similar materials. They are completely blowout-proof, prevent seepages of oil from crankcases, and reduce time in shops for replacement of worn gaskets. The 80-mesh copper and rubber have high tensile strength, flexibility, resiliency, oil resistance, dimensional stability and accuracy.

● A one-piece industrial thermometer that saves critical materials has been put out by *Taylor Instrument Cos.,* Rochester, N. Y. The case is shallower, making it possible to see the mercury column through a wider angle of vision. The chromium-plated bezel fits snugly into the grooved case so as to hold the thick glass front securely against four wavy tension springs. Hence it is all dustproof, rattleproof and practically fumeproof.

## Sprayed-On Vitreous Coatings

"Silco" is a new sprayed-on vitreous coating, which substitutes for plating materials. Inorganic in nature, it resists acids, mild alkalis, rust, corrosion, heat, impact, abrasion, etc., and is a dull finish that may be buffed to a beautiful eggshell gloss.

Made by *Mitchell-Bradford Laboratories,* 2446 Main St., Stratford P. O., Bridgeport, Conn., Silco is sprayed, dried at 200 deg. F., and baked at 350 deg. F. in convection-type oven or by infra-red lamps, and is a type of vitreous enamel minus the handicap of high-temperature baking.

At present it is produced in black, army drab and navy gray. It withstands heat up to 1000 deg. F., and is not affected by a 200-hr. salt spray test. It is not flexible, though will bend 30 deg. without breaking. The thickness coating is 0.0001 to 0.0002 in.

Some of the jobs now done are gasoline engine exhaust manifolds, mufflers and pipes; steel boxes for parts in shop work; as a container lining for organic lacquers and solvents.

● One of the secrets of making cartridges of steel rather than brass is the use of "non-directional" steel, states John M. Olin, vice president, *Western Cartridge Co.,* East Alton, Ill. Ordinary steel has a "directional" grain-like wood, and under the tremendous pressures of drawing it has a tendency to crack along the grain lines. Under the Western process, non-directional steel, in which the grain does not run in a single direction, produces smooth, even draws.

## Inspector's Stamping Kit

An etching stamp kit for use by inspectors in the marking of precision parts and assemblies with acid etching inks has been brought out by *Jas. H. Matthews & Co.,* 3942 Forbes St., Pittsburgh. The stamps are unaffected by the acid etching inks. The unit is light and easily carried by the inspector.

The kit holds four stamps; ink is kept in one bottle and oil or neutralizer in the other. A stamp pad is kept in the drawer at the front of the unit. A glass tube is provided to re-ink the pad. After the stamp is inked and withdrawn, the cover closes automatically, thus preventing acid fumes from escaping.

After marking the part, the inspector places a drop of oil or neutralizer upon it.

● A threat to the supply of starch as a core binder for foundries because of the fast diminishing corn supply is voiced by *Corn Industries Research Foundation,* 5 E. 45th St., New York. It points out that this corn starch famine is due to the corn-hog policies of the Secretary of Agriculture, which makes it more profitable for the farmer to sell hogs than corn. Thus, corn goes to the hogs instead of coming to market. Corn refiners are using 130,000,000 bushels of the 1943 estimated crop of 3,000,000,000 bushels.

## Novel Spring Testing Machine

Production of fuze springs for various types of projectiles is an exacting task, since improper functioning causes the projectile to explode at the wrong time, wasting part of its effectiveness, or failing to go off altogether. Close tolerance testing of these springs was formerly a most tedious job.

However, *American Steel & Wire Co.*, Rockefeller Bldg., Cleveland, invented an intricate device that not only examines them rigidly, but sorts and classifies them according to length, load capacity and deflection. Speed has been stepped up to 2500 springs per hr.

They are placed vertically into small holes in a large metal disc, which is then placed in a machine and rotated, allowing each spring to stop momentarily at each of several testing stations, in circular formation. The first station pre-sets the spring, the second tests for excess length, while a third, for shortness. The fourth tests for load, and a fifth for deflection.

If a spring fails to meet requirements at any one station, a slide underneath opens and allows it to drop into a compartment below. A spring that passes through all stations is naturally satisfactory.

● A new diamond dressing tool that fits most standard grinding machines is introduced by the *Koebel Diamond Tool Co.*, 9456 Grinnell St., Detroit. Known as "Kodi," it does away with the need for a special dresser for each machine. It is supplied with a special shank or Ko-Adapter, fitted with a recessed head set screw, which locks the standard Kodi nib in position. Once installed, it remains on the machine, with only the nib removed for resetting or replacement.



## Shape Cutting Machines

All cutting jobs, from the smallest up to an overall size of 3 ft. x 4 ft., can be handled by the new Type JR shape cutting machine, put out by the *National Cylinder Gas Co.*, 205 W. Wacker

Drive, Chicago. The maker claims that cutting can be held to close tolerances, that the top and bottom edges are clean and sharp, that there is no adhering slag, and that the cut surface is smooth, so that further machining or grinding are, in many cases, eliminated.

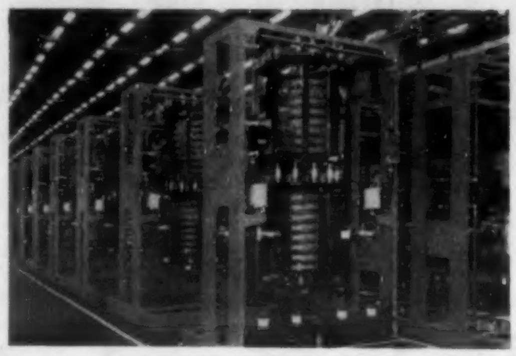
Among its many features are the uniform speed of travel from 2 to 35 in. per min., the friction-free movement of the entire carriage, and the vibration-free construction of the torch-holding mechanism.

● New "wrinkle" finishes, containing no Chinawood oil, are announced by *Maas and Waldstein Co.*, 438 Riverside Drive, Newark, N. J. They form hard, durable coatings, and cover rough metal surfaces effectively in a single coat. They are in a full range of colors.

## 1400 Kw. for Electronic Tin Fusing

When electrolytically deposited tin-plate on steel strip is flowed into a smooth, shiny surface, the key units behind the induction coils are power rectifying tubes, high-frequency oscillator tubes, and oscillator tank circuits.

D.c. power at 17,000 volts is applied to the vacuum tube oscillators, whereupon it is converted to high-frequency a.c. power of 200,000 cycles per sec. and fed into the tuning circuit. Water-cooled copper conductors carry this high-frequency power to the induction heating coil that surrounds the tinned strip.



Seven of these 200 kw. tuning units are shown in the accompanying photograph during assembly at the *Westinghouse Radio Div.*, Baltimore.

## Electronic Level Controls at Hazardous Sites

A new series of electronic level controls for hazardous location mounting has been brought out by *Photoswitch, Inc.*, 21 Chestnut St., Cambridge, Mass. They are for use with conductive liquids of an explosive nature. Two models, P15NHX and P15NLX, are for high- and low-level control, respectively. Each is a complete unit in a vapor-proof cast iron housing for direct tank installation.

A nipple screws into the hub at the bottom of the control housing and is screwed into a flange on top of the tank. From the control, a probe rod projects through the nipple and into the tank to the desired depth.

High-level control is accomplished when liquid rises and contacts the probe tip; low-level control when liquid drops below the tip. A safety feature provides for operation of the relay in case of current or tube failure.

## Water-Jacketed Dies for Propellers

For the first time on record anywhere, water-cooled cast-to-form dies have been used in propeller blade manufacture at the *American Propeller Corp.*, Toledo, Ohio, it is claimed.

The blades are made of alloy steel, and in the course of production several hot and cold forming operations are done on Meehanite cast-to-form dies, thus eliminating considerable die sinking.

Water-jacketed dies used on finished blades as they are quenched to final hardness are illustrated in the accompanying photograph.

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# News of Men, Societies, Meetings and Companies

## Plants and Slants

The evil eye and jittery jinx are being placed on Schickelgruber (Adolf, his mama called him) by the merry welders, tried and true, of *North American Aviation, Inc.*, Dallas, Tex. These voodoo masks will cast a hoodoo over the smart boy dictators — assisted, of course, by airplanes, tanks and ships. The mask in the center is not to be confused with Tojo — any similarity is merely coincidental. The picture is presented through the courtesy of *Lincoln Electric Co.*, Cleveland.

*Nightmares for Hitler!*

In a new 4-acre blackout plant on the East Coast, an innovation is the handling of interior traffic that flows next to the side walls, leaving the remaining areas clear. The plant is for the production of special-type radio equipment for the army, and is sponsored by *Westinghouse Electric & Mfg. Co., Radio Div.* The plant saved 1,920 tons of steel by the use of 1,554,000 ft. of lumber. More than an acre of pressed wood panels were used in place of glass. There are nearly two miles of tubular fluorescent lamps to simulate daylight working conditions.

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In a new Detroit plant, all air is passed through a dust collecting and washing installation, which not only maintains a more even plant temperature, summer and winter, but also increases the quality of the finish of the product. The plant is that of the *Colonial Broach Co.*, Hoover Road, and more than quadruples productive floor space. A feature is the extensive heat-treat department, said to be the most complete in the broach industry.

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Production of magnesium metal has begun at the new magnesium-chlorine plant in Louisiana of the *Mathieson Alkali Works, Inc.* It has a future capacity of over 50,000,000 lbs. of magnesium a year. Principal raw material is dolomite. This ore is calcined with local natural gas. Resulting oxides are treated with calcium chloride, then with carbon dioxide obtained from the calcination of the dolomite, converting the calcium into insoluble carbonate, leaving magnesium chloride. This is electrolyzed, forming magnesium and chlorine.

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*Phelps Dodge Copper Products Corp.* plans to engage in the manufacture of aluminum and magnesium tubes, rods and shaped parts, produced by the extrusion process, primarily for the airplane industry.

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*Carnegie-Illinois Steel Corp.* started producing steel recently at an expanded plant at Homestead, Pa. when the first of eleven 225-ton open hearth furnaces went into operation. When completed, the new open-hearth shop will have an annual capacity of 1,500,000 tons of steel ingots. The new shop is within a stone's throw of the site where Andrew Carnegie produced the first open hearth steel in the United States 55 years ago. The plant will be manned by about 3,000 workers.

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Production of clinkered or double-burned dolomite was begun recently at a new kiln plant, just completed under the direction of *Basic Refractories, Inc.*, Cleveland, in behalf of *Defense Plant Corp.* The new unit, one of the largest of its kind in the world, adjoins the main burning plant of Basic at Maple Grove, Ohio.

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The society editor of the leading newspaper at Bridgeport, Conn. appealed for women help in war plants on behalf of *Jenkins Bros.*, valve manufacturers. A full-page display ad was run in the Sunday Bridgeport Herald, signed by Doris Nicholas, society editor. In chatty style, Miss Nicholas appealed to those with diamonds, as well as those with washboards, to get into war work.

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The new brick and clay plant of *General Refractories Co.*, Philadelphia, at Troup, Texas, will be in production in late summer. Native clay will be made into firebrick. The company has also bought the assets of the *Refractories Corp.*, of Los Angeles, Calif.

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*Lindsay and Lindsay* have purchased a new plant at 4818 So. Rockwell St., Chicago, which will make it possible to triple the company's output.

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*A. P. de Sanno & Son*, Phoenixville, Pa.,

manufacturers of grinding wheels and cut-off machines, have opened up a Philadelphia office for machine sales and export, maintaining a large cut-off laboratory in the basement.

*Webster-Chicago Corp.* has sold its Armitage Ave. plant to *Webster Products.* Webster-Chicago will continue as engineers, designers and manufacturers of tools and dies, metal stampings, machine parts and special apparatus.

*Inland Steel Co.* has taken over the operation of Hillside Fluor Spar Mines in Rosiclare, Ill., through the purchase of all capital stock.

John D. Gordon announces the formation of the *Detroit Electronic Laboratory,* 10345 Linwood Ave., Detroit. Included among the products produced will be tubes for control equipment for resistance welding.

## News of Engineers

*Harold E. Hall* has been elected president of Metals Disintegrating Co., Inc., Elizabeth, N. J., manufacturers of metal powders for powder metallurgy and pigment uses. He has been general manager of the company for the past six years.

*Charles F. Rohleder* has been appointed factory superintendent of Maas & Waldstein Co., Newark, N. J., maker of industrial finishes. He has been chief chemist of that company since 1937. Since graduation in 1926, his professional life has been spent in the industrial finishing field.

*Carl H. Vaupel* has been appointed assistant general manager over the two plants of Cooper-Bessemer Corp., Mt. Vernon, Ohio. Much of his early experience was with the Diesel Engine Div., Fairbanks, Morse & Co., Beloit, Wis., where he worked in experimental research and engineering departments. *Willard A. Luli* has become factory production representative, located at Washington and dealing with allocation of materials.

*Melvin G. Willigman* has joined Battelle Memorial Institute, Columbus, in the Mineral Dressing Research Division. He has a master of science degree from the University of Arizona, where he majored in chemistry and metallurgy. He was formerly with the U. S. Bureau of Mines. *Clarence E. Levoe,* a recent graduate in metallurgical engineering of the Colorado School of Mines, has joined Battelle and will do research on the high-temperature properties of metals.

### Wanted: Metal Salvage Man for Navy

*Men who have three or more years of experience in the salvage and reclamation of scrap metals may qualify as commissioned officers in the Navy. Applicants must be 27 to 43 years old. A college degree in metallurgy or metallurgical engineering is desirable, but not mandatory. Candidates should have had three or more years of experience in the salvage and reclamation of scrap metals or used materials. Their earnings and relative position should be on an executive level.*

*Those lacking specific experience in salvage may qualify if they have had three or more years experience in the following: production of metal equipment, machining experience, all types of metals, or handling and use of heavy industrial equipment. Men with only two years of college work in metallurgical engineering, plus a background of experience in engineering shops, steel or smelter plants, may qualify. Application can be made at any Office of Naval Officer Procurement.*

*Edward G. Budd,* founder and president of the Edward G. Budd Mfg. Co., Philadelphia, was awarded a "Pioneers of Industry" recognition for outstanding service to the industrial community of Philadelphia by the Murrell Dobbins Vocational School. The text of the award reads: "He started as a machinist, and has not now lost contact with the worker, though the head of several large war plants."

*Walton L. Woody* has been elected vice president in charge of operations of the National Malleable & Steel Castings Co. He had been assistant to the president and in charge of the Sharon, Pa. and Melrose Park, Ill. works. He joined the company in 1914 and established the company's first chemical laboratory.

*John W. Haddock,* formerly vice president in charge of engineering and sales of Sullivan Machinery Co., Michigan City, Ind., has become president of the Farrell-Birmingham Co., Ansonia, Conn. He is a member of several technical societies.

*Raymond R. Ridgway,* associate director of research for Norton Co., Worcester, Mass., was awarded the Jacob F. Schoellkopf medal for 1943 at a meeting of the Western New York section, American Chemical Society. He has a long list of inventions in the design of electric furnaces for the production of abrasives. His isolation and commercial production of boron carbide was outstanding.

*Bert Conway,* who has been with General Motors Corp. for the last 22 years, has been named manufacturing coordinator for the Aviation Corp., Detroit. He will be in direct charge of production and tooling at all Aviation Corp. plants. He has been with Chevrolet, Pontiac, Allison, Ford and other companies.

*A. E. Bedell* has been appointed chief engineer of Graver Tank & Mfg. Co., Inc., East Chicago, Ind. He has had much experience in the chemical, power, sugar and general industrial fields.

*Louis G. Marini* has been appointed assistant general manager of the Alloy Rods Co., York, Pa. He was formerly process engineer in charge of production of arc welding electrodes for Westinghouse at Trafford, Pa.

*George Johnstone, Jr.* has been made foundry superintendent of the Grove City, Pa. plant of Cooper-Bessemer Corp., having formerly been assistant superintendent. He taught foundry practice at Girard College, Philadelphia, for several years and has had much experience in the field.



## Briefs on Associations, Promotions, Education

A new trade association in the metals field sprang into being just at the time an old-timer, the National Association of Flat Rolled Steel Manufacturers, went out of business. The new association is the *Pressed Metal Institute,* 19 W. 44th St., New York, organized March 17 by some 60 representatives of sheet and strip metal fabricators, rolling mills and metal press manufacturers. It will cooperate closely with Government departments to increase mass production, and will develop new uses for metal stampings for post-war. Another office has been established in the Press Bldg., Washington. The new president of the institute is George E. Whitlock, president, Mullins Mfg. Corp., Warren, Ohio.

*Twenty married couples are working together at the Duquesne, Pa. works, Carnegie-Illinois Steel Corp. Typical are the Medowskies. George has worked in the open-hearth department for 18 years. Theresa racks steel bars in a cradle at the end of a shear line and says: "My mill work is not half as tiring as housework."*

Investigation and development of the possibilities of heating steel and other materials with gas at speeds heretofore unattainable is the subject of a new research project of the *American Gas Assn.* It is believed by many that long-established heating cycles can be greatly reduced in time with important metallurgical and economic benefits. Modern gas-air combustion will be compared through studies with conventional furnace heating, electric induction and oxy-acetylene.

*An estimated 40,000 men and women in industry have been trained in the fundamentals of proper design, grinding, brazing and application of carbide tools during the past five months through silent slide*

*training films, according to Carboloy Co., Inc., Detroit. Widest use has been by supervisory groups (90 per cent), followed closely by tool grinder hands. More "old" hands than new saw the films. Even draftsmen and designers showed interest.*

An ambulance, fully equipped, was presented to the Army on June 1 by the Women's Auxiliary of the American Institute of Mining and Metallurgical Engineers, the presentation having been made by Mrs. Thomas T. Read, president.

*"The Spirit of Enterprise" is the title of a new book by Edgar Monsanto Queeny, chairman, Monsanto Chemical Co. The author believes that the best interests of the people will be served by a free enterprise economy as opposed to a strong, centralized bureaucracy. Among the author's several affiliations are: director of the National Bearing Metals Corp., and former vice president of the National Association of Manufacturers.*

Roe S. Clark, vice president and treasurer, Package Machinery Co., Springfield, Mass., has been re-elected president of the *National Metal Trades Assn.*

*"The typical American is a chronic grouser who is always finding fault. This is encouraged in the Army and should be encouraged in our production army. Developing a good suggestion involves merely turning a grouse into a constructive idea. The trouble is that most people stop at the initial fault-finding stage." So spoke Charles R. Riker, suggestion system coordinator for Westinghouse, at a meeting of the National Association of Suggestion Systems in New York.*

## Meetings and Expositions

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Salt Lake City, Utah. September 2-4, 1943.

AMERICAN CHEMICAL SOCIETY, semi-annual meeting. Minneapolis, Minn. September 6-10, 1943.

SOCIETY OF AUTOMOTIVE ENGINEERS, national tractor meeting. Milwaukee, Wis. September 23-24, 1943.

ASSOCIATION OF IRON AND STEEL ENGINEERS, annual meeting. Pittsburgh, Pa. September 28-30, 1943.

SOCIETY OF AUTOMOTIVE ENGINEERS, national aircraft engineering and production meeting. Los Angeles, Calif. September 30-October 2, 1943.

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By *Edwin F. Cone*

## A Night Shift of White Collar Workers

A special night shift has been created at the Bridgeport, Conn., plant of Jenkins Bros., manufacturers of valves. It is made up of resident white collar workers and operates from 6 to 11 p.m., five days a week. They work in the plant as tool designers, toolmakers, and on the machine benches and consist of bankers, brokers, attorneys, business executives, salesmen, bookkeepers, etc. "They realize the vital importance of the company's products in the shipbuilding program, and are motivated by patriotism and a sincere desire to share in the war effort." This development is reported a decided success. It is worthy of adoption by other plants.

## Metals and Plastics

In combination with metals, plastics will assume a prominent role in post-war activities, said Jack Delmonte in an address before the Society of the Plastics Industry. He looks for the day when every metal-working establishment will have a plastics division. These two materials can be designed in a complementary rather than a competitive manner — metal casings in molded plastics, resin-bonded metal fillers, metal plated plastics, and plastic-sealed metal castings.

## New Record in Welding Wire Output

An index of the spread of the war effort and the expanding use of welding is the production of welding wire in 1942. Official data of the American Iron and Steel Institute indicate that 800,400,000 lbs. of such wire were made last year or nearly double the 453,120,000 lbs. for 1941 and more than 3 times the production in 1940.

Almost 13 lbs. of welding wire were made in 1942 for each ton of finished steel produced compared with over 7 lbs. in 1941 and 5 lbs. in 1940. In 1938, a year before the war broke out, about 4.9 lbs. was the comparative figure.

## More Women in Steel Mills

Women are entering all departments of American steel mills, according to testimony at the annual open-hearth conference this year. A representative of the Republic Steel Corp. testified that it has over 5,000 women working in its plants. Many other mills recognize that before the year's end the use of women will likely approach the British level of some 12 to 15 per cent. So far in the United States it is agreed that the use of women in steel plants has not resulted in any loss of efficiency — in certain cases there has been a gain in efficiency and a decline in absenteeism.

## Future of Induction Heating

There is no doubt but that the use of induction heating will increase rapidly in the immediate future, for all types of heating operations—hardening, annealing, brazing, soldering, forging and melting, said Frank W. Curtis, chief engineer, Van Norman Machine Tool Co., Springfield, Mass., in an address before the meeting of Westinghouse foremen at Pittsburgh in April. "Many changes in our methods of manufacture will result because of the speed with which heat can be produced by high-frequency currents. Add to this the uniform results that induction heating offers, and it is obvious that this process will make possible the handling of jobs which can be done in no other way."

## Steel Shell Cases

Each shell case of steel produced saves about 3 lbs. of copper, conservation running into thousands of tons, according to Buick officials. They have thus "found" thousands of tons of copper. And Buick is producing large caliber steel shell cases "by the hundreds of thousands" without in effect dipping into the nation's steel supply. It is claimed that enough steel is being saved in the forging processes on aircraft engines and tank parts to meet steel shell case requirements at top production. "The net result is a production 'gift' to Uncle Sam of literally millions of pounds of copper and millions of steel shell cases to boot without drawing upon metal resources."

## Substitutes for Metal Containers

Cardboard and other containers are rapidly displacing metal. The changeover of one type of tobacco container from tin to cardboard has made available for war production almost 7,000,000 lbs. of tinplate. Other tobaccos have been similarly packaged with similar savings. One manufacturer of cookie boxes has released over 2,000,000 lbs. of tinplate by changing to paper board containers, says a statement from the WPB.

## Steel for Ships

The No. 1 consumer of finished steel in 1942 was the shipbuilding industry—for the first time on record. The American Iron and Steel Institute announces that at least 9,425,000 net tons of steel products was sent to shipbuilders for fabrication into ships, Navy and merchant. This represented about 16 per cent of the total tonnage of products shipped by steel plants to all classes of consumers. The construction industry was second at 8,656,000 tons or 14 per cent of the total.